Master's thesis

NTNU
Norwegian University of Science and Technology
Faculty of Architecture and Design
Department of Architecture and Technology

Anastasia Tsivileva

Nordlandsbua
Cabin in Nordlandsruta

Materials selection and life-cycle analysis

Master's thesis in Master of Science in Sustainable Architecture
Supervisor: Pasi Aalto
Co-supervisor: Patricia Schneider-Marin, Tommy Kleiven
May 2022

NTNU
Kunnskap for en bedre verden

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ABSTRACT

Following a particular order from DNT and their sustainability strategy for 2050, our team has developed a compact shared cabin that could become a new example of sustainable design in this area of construction. In May 2022, the cabin was built in Bodø for demonstration at the Norwegian Friluftslivskonferansen exhibition and for further transportation and operation on the Nordlandsrutta track.

Since the project is a realizable prototype, it is subject to increased requirements for the choice of materials and construction processes. During the study, the selected design solutions and different materials were analyzed, which allowed us to build a prototype and make suggestions for the future cabins that may appear.

The study includes a life-cycle analysis of the built and proposed projects and an analysis of the possibilities for the circulation of recycled materials using the example of a prototype. The structure's weight for all three types of cabins is also calculated and analyzed.

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Finally, I would like to dedicate my thesis to my best friend Nikita Chervyakov, who left this world untimely in the summer of 2021. I wish to share this achievement with you, dear friend.

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ABBREVIATIONS

DNT	Den Norske Turistforening
NTNU	Norwegian University of Science and Technology
LCA	Life-Cycle Assessment
CO2	Carbon Dioxide
CO2EQ	Carbon Dioxide Equivalent
EPD	Environmental Product Declaration
kWh	KiloWatt - Hour
BIM	Building Information Model
OSB	Oriented Strand Board

1. INTRODUCTION

BACKGROUND

Today, in Norway, the culture of owning a cabin exists almost everywhere. There is a trend that the number of square meters in new cabins is growing along with an increasing list of modern amenities and delights, which directly affects the amount of materials and energy resources spent. However, a cabin is not a permanent residence but a vacation location that remains empty for more than 75% of the days of the year, which has a substantial environmental impact. This fact does not fit into the concept of a climate-neutral economy by 2050. The DNT team, in collaboration with NTNU, proposes a shared cabin project that could change the impact of the "cabin industry" on the environment by rethinking the cabin's privacy and sizes.

The design of the booth prototype was developed jointly by four students of master's programs. In parallel with the development of design, each student individually delved into one of the important research topics, such as:

- Materials selection and emissions from materials
- Thermal and energy sources
- Analysis of climatic factors and their influence on the initial design
- Circular economy of the building

This thesis is devoted to describing the chosen construction technology and selection of materials, the life-cycle analysis of the prototype, and the possibility of introducing circular materials both into the prototype project and subsequent projects related to the prototype.

GOALS AND SCOPE

The main goal of this thesis is the successful construction of a cabin for its further presentation at the exhibition and operation on the Nordlandsrutta trail. Since this is a comprehensive goal that includes a complex of decisions and studies, this thesis will review the critical points of the study on the choice of building materials. This study includes:

- Analysis of the design solutions of the prototype to understand the necessary layers of all structural and enclosing elements of the building
- Analysis of the proposed and selected materials currently available on the local market
- Calculation of the required amount of materials, preparation of documentation for ordering materials
- Study of the possibilities of introducing circular materials into this project
- Analysis of mistakes in the selection of materials
- Prototype's life-cycle analysis

In addition to the main goal, dedicated directly to constructing a prototype, there is a secondary one. Since, if successfully implemented, the project can become massive and be located along the entire length of the Nordlandsrutta trail, there is a need for a more significant analysis of the possibilities of the materials used. One of the key objectives throughout the project is the selection of future materials and the ability to use previously used materials in construction. Given the limited time frame for constructing a prototype cabin, not all possibilities for re-using materials can be realized. Therefore, studying the limits of the use of circular materials in later versions of cabins and comparing different LCAs is the second goal of this thesis.

METHODOLOGY

The project methodology can be divided into two main parts - design methodology and individual research methodology. Let us focus on the methodology of this personal research. All decisions at all stages of design, including the choice of materials and construction methods, were discussed with the focus group of the customer DNT, a group of

carpenters from Germany, and a team of mentors led by our supervisor Pasi Aalto.

Presentation meetings with DNT were held every one and a half months. Representatives shared their expectations from the project, put forward their requirements for using specific materials and construction technologies, gave valuable advice, and were inspired by our project vision. A critical condition when working with the customer was considering the practical experience of operating shared cabins, which later influenced the adoption of one or another decision.

Over the past few months, before the start of construction, there was an active discussion with the construction team from Germany, led by Anton Lieb, both by video meetings and e-mail. Such cooperation partially helped to understand the upcoming technological processes of construction, which indicated some gaps in the calculation of materials, the creation of structural units, and layers of enclosing elements. In the future, the discussion continued at the construction site, which made some adjustments to the cabin's design and the materials used.

Meetings with the supervisor were held every two or three weeks, where we discussed the work which was already done and the work plan for the following days. The supervisor team shared their practical experience in designing cabins and small dwellings, which helped prioritize the choice of certain types of materials and construction technologies.

The whole process can be divided into the following sequential steps:

1. The study began with creating a simple computer model in the Revit program with the basic values of materials for building envelopes without detailing.

- The model was created to approximate the proportions of the volumes of materials for certain enclosing elements of the prototype

2. Further, in parallel with the design study, a detailed computer model was built in the Revit program.

- The model was changed and supplemented every day, the file was on the server for the possibility of collaboration with colleagues on the project

- Tables of materials were created, and each element was assigned the correct material with exact dimensions

- Structural units were created, which were discussed with the construction team

3. Then, an informative table of materials was created in Excel, where material options for each type of enclosing element were entered layer by layer.

- Each material had data behind it, such as layer number, name, function, dimensions, density, units of measurement, sustainability factor, pros, cons, purchase link, EPD link, and fields for importing the required volumes from the digital model

- Another project participant also used the table to calculate, for instance, heat losses through the building envelope

- With the help of the table, the cabin weight calculations were made at different design stages

4. By examining the selected materials through the prism of factors such as market availability, weight, environmental friendliness, customer request, architectural aesthetics, and recyclability, construction materials were identified.

- All materials appear in the table with the necessary characteristics and links

- Alternative materials have been found to be used instead of initially chosen materials for constructing the prototype

- A study was carried out on replacing selected new materials with circular materials for implementation in subsequent related projects

5. Then, the final count of the amount of materials was made through the model in Revit. The results were exported to an Excel table, which made it possible to approximate the structure's weight, which is essential for transportation from the exhibition site to the final destination, and proceed to order materials.

6. Next, a list of orders was compiled, indicating the required quantity of each material, in m or m2, with links to distributors.

7. Some changes were made to the cabin's design and structure at the construction site, and some materials were also changed.

- The BIM model has been updated with all the changes
- New structural drawings were created
- A new table of materials used in construction was created
- The new weight of the building has been calculated

8. An analysis of the embodied emissions from materials based on the building's life cycle assessment (LCA) was carried out using the One-Click LCA program.

- First, an LCA analysis of the prototype was carried out, which made it possible to determine the approximate emissions from the materials of the project being implemented
- Then, an LCA analysis of the alternative cabin was made, where all materials would be new, and the mistakes made during the prototype development would be corrected
- In the end, an LCA analysis of the alternative cabin was made, where the maximum amount of new materials was replaced with re-used materials
- Norwegian Environmental Product Declarations (EPDs) were used as much as possible for calculations

9. The last step was to compare three cabins and their LCAs with different amounts of circular materials used.

Finally, the main findings, limitations, and further work are discussed.

II. MATERIALS

RESEARCH BOUNDARIES AND LIMITATIONS

One of the most significant stages of the project was the selection of building materials for the cabin. Since the project involved the construction of a 1:1 prototype in May, there were limits to the choice and use of certain materials. In total, these restrictions can be divided as follows:

1. Availability of materials in the local market

One of the main restrictions in choosing materials was their availability for purchase in the period from April to May. First of all, materials that could be found directly in Bodo and transported to the construction site without high logistical costs were considered. Alternative methods were considered if the quality, properties, or appearance of the materials offered on the market at Bodo did not meet the requirements of the initially selected materials. Some materials could be ordered from a warehouse or other cities, subject to the delivery deadlines. Some of the materials were brought in by our student team from Trondheim, mainly used interior materials that were dismantled and subsequently given away free of charge or sold to us.

2. Weight of materials

An essential role in decision-making was the weight of a particular material. In terms of construction, the prototype project is unique, as it will be erected at the construction site in Bodo, transported and demonstrated at the Norwegian Friluftslivskonferansen exhibition, and only then transferred to its final destination. The carrying capacity of the lorry, which will move the booth from the exhibition to the nearest transport-accessible point, can reach 44 tons. However, to transfer the prototype from this point to the site, a helicopter or crane truck may be required, the carrying capacity of which does not exceed 3,6 and 5,5 tons, respectively. Thus, it is advisable to strive for reduced weight of the prototype, which in no case should exceed 3,6 tons.

3. DNT and building team recommendations

Also, when choosing materials, special attention was paid to the requirements and wishes of the customer. Since DNT deals with many cabins throughout Norway, they are aware of the problems that arise with materials, whether they are problems in operation, replacement, unsuitability for use in cabins, and others. After an informative conversation with representatives, some types of insulation were crossed out from the list of proposed materials, some types of wood were added for consideration, and so on. The team of carpenters from Germany influenced the choice of the materials and the economic planning of their use in the project.

4. Good environmental passports of materials

Another critical factor was the sustainability of the selected material. The selected materials should, at best, be made on the territory of Norway, at worst, on the territory of mainland Scandinavia. The amount of emissions to the atmosphere should be reduced to the maximum extent, which should not interfere with the balance of this condition with those listed earlier.

5. Appearance, architectural and aesthetic value of the material

One of the goals of the prototype is to demonstrate a comfortable life in a shared and small cabin. In order to convince people to refrain from building new private cabins and choose shared ones, it is necessary to create an emotional connection between the user and the place. It will be impossible to achieve such an effect without a beautiful visual component, pleasant to the touch, and comfortable to use materials.

6. Resistant materials against harsh weather, pests, rapid aging

Since the cabin will be located far from civilization, in rather harsh natural conditions, without constant human supervision, the materials must withstand a long time without maintenance, but at the same time continue to perform their

influence and without harming them.

7. Ability to reuse materials in the future

This factor very often runs counter to other factors, as it implies minimum material processing, which is not consistent with some other conditions.

Thus, the choice of materials depends on many factors. The key message in building the prototype was to achieve some balance in all categories of factors without delving into just one, forgetting the importance of others.

MISTAKES

Although the work on the prototype design was carried out under the guidance of many specialists, there was always room for mistakes. We were given much freedom to choose, design, and explore, which included the positives, such as making our designs a reality, and the negatives, such as inevitable errors and consequences. Most of the mistakes were made due to design decisions and the choice of incorrect materials for specific building layers. They were made due to a lack of practical experience among the team members.

Some errors were discovered and corrected during construction. For already committed and/or irreparable mistakes, a quick solution had to be found at the construction site. Subsequently, all miscalculations were discussed within the thesis group, and with the supervisor, construction team, customer, and solutions for future cabins were found.

However, the experience of making mistakes is not exclusively negative. Thanks to this experience, practical knowledge were gained about the structural elements of the building, the materials, and their practical areas of use. In this thesis project for the LCA of the prototype, the actual materials used are observed, even if, in the end, their choice was erroneous. However, these mistakes were taken into account and corrected for the LCA of the “ideal” cabin, both with and without circular materials.

DEFINITION OF BUILDING LAYERS

In order to study the selected materials, first, one needs to understand the number of primary elements of the building and their composition. The cabin consists of the following elements - walls, floors, roof, superstructure, windows, and doors (Table 1). Since the cabin prototype has already been built, the number of building elements and their composition is based on a real example. However, the addition or exclusion of the layer is not exepted for further consideration.

SUPERSTRUCTURE

The building is a platform framing structure in which a separately erected wall structure is installed on top of the floor structure. The floor structure is two connected platforms consisting of trimmings and floor joists. Beams of different sizes were used, with a cross-section of 48 millimeters by 98 millimeters and 48 millimeters by 148 millimeters, respectively. Their size was determined based on the required thickness of the insulation and based on the concept of a multi-level space inside the cabin. The trimming length of the first platform is 3.048 meters; the second platform is 3.6 meters. The span of floor joists is 1,948 meters, and the distance is 60 centimeters meters from center to center. Hunton’s sizing charts were used to determine the height of the beams.

The construction of the walls is a system of studs supported by bottom and double top plates. The size of the studs in cross-section is 48 millimeters by 98 millimeters, in length from 2.18 meters to 2.3 meters. Their size was determined after heat loss calculations based on the required insulation thickness. The distance between studs is not universal and runs between 74 mm and 600 mm from center to center. This decision was due to the further installation of planar surfaces and their attachment to studs.

The roof beams are arranged on top of the walls top plates and are located at an angle of 3.5 degrees. The need for this slope and its size were determined by two factors - the possibility of subsequent operation of the

the roof and the protection of the structure from weather conditions such as snow and rain. The size of the beams in the cross-section is 48 millimeters by 148 millimeters, in the length is 2.355 meters. Insulation thickness calculations determine the cross-section size; transport restrictions determine the length of the beams.

EXTERIOR WALLS

In total, three types of external walls can be identified in the cabin, differing in composition (Figure 1). The first wall type is located in the drying room. It consists of six layers: exterior cladding, cladding battens, wind barrier, superstructure and insulation, vapor barrier, and interior lining 1.

The second type of wall is located in the cabin and consists of seven layers: exterior cladding, cladding battens, wind barrier, superstructure and insulation, vapor barrier, air gap/battens or interior lining 2, and heat protection.

The third type of wall is the most common in cabin design and consists of six layers: exterior cladding, cladding battens, wind barrier, superstructure and insulation, vapor barrier, and interior lining 2. All three types of walls are very similar in composition but differ in the required materials.

INTERIOR WALL

There is only one inner wall separating the cabin from the drying room in the building (Figure 1). The composition of this wall differs from the outer walls and consists

Conctruction element	Type	Description	Location
Superstructure	ST1	Studs 48 mm * 98 mm	Cabin and drying room
	B1	Beams 48 mm * 98 mm	Floor structure in cabin's dirty zone, drying room and terrace
	B2	Beams 48 mm * 148 mm	Floor structure in cabin's clean zone and roof structure
	CB1	Cross bracing 48 mm * 98 mm	Cabin and drying room
Exterior walls	EW1	Stud wall 48 mm * 98 mm, with insulation	Drying room
	EW2	Stud wall 48 mm * 98 mm, with insulation and heat protection	Cabin
	EW3	Stud wall 48 mm * 98 mm, with insulation	Cabin
Interior walls	IW1	Stud wall 48 mm * 98 mm, with insulation and heat protection	Between drying room and cabin
Floors	IF1	Floor 48 mm * 148 mm, with insulation	Cabin, clean zone
	IF2	Floor 48 mm * 98 mm, with insulation	Cabin, dirty zone
	IF3	Floor 48 mm * 98 mm, with insulation	Drying room
	EF1	Therrace floor, without insulation	Terrace
Roofs	R1	Roof , with insulation	Cabin, drying room and terrace
Windows	W1	Window 40 mm * 100 mm	Cabin
	W2	Window 110 mm * 120 mm	Cabin
Doors	D1	Door 2000 mm * 800 mm	Cabin and drying room

TABLE 1. Elements of the cabin

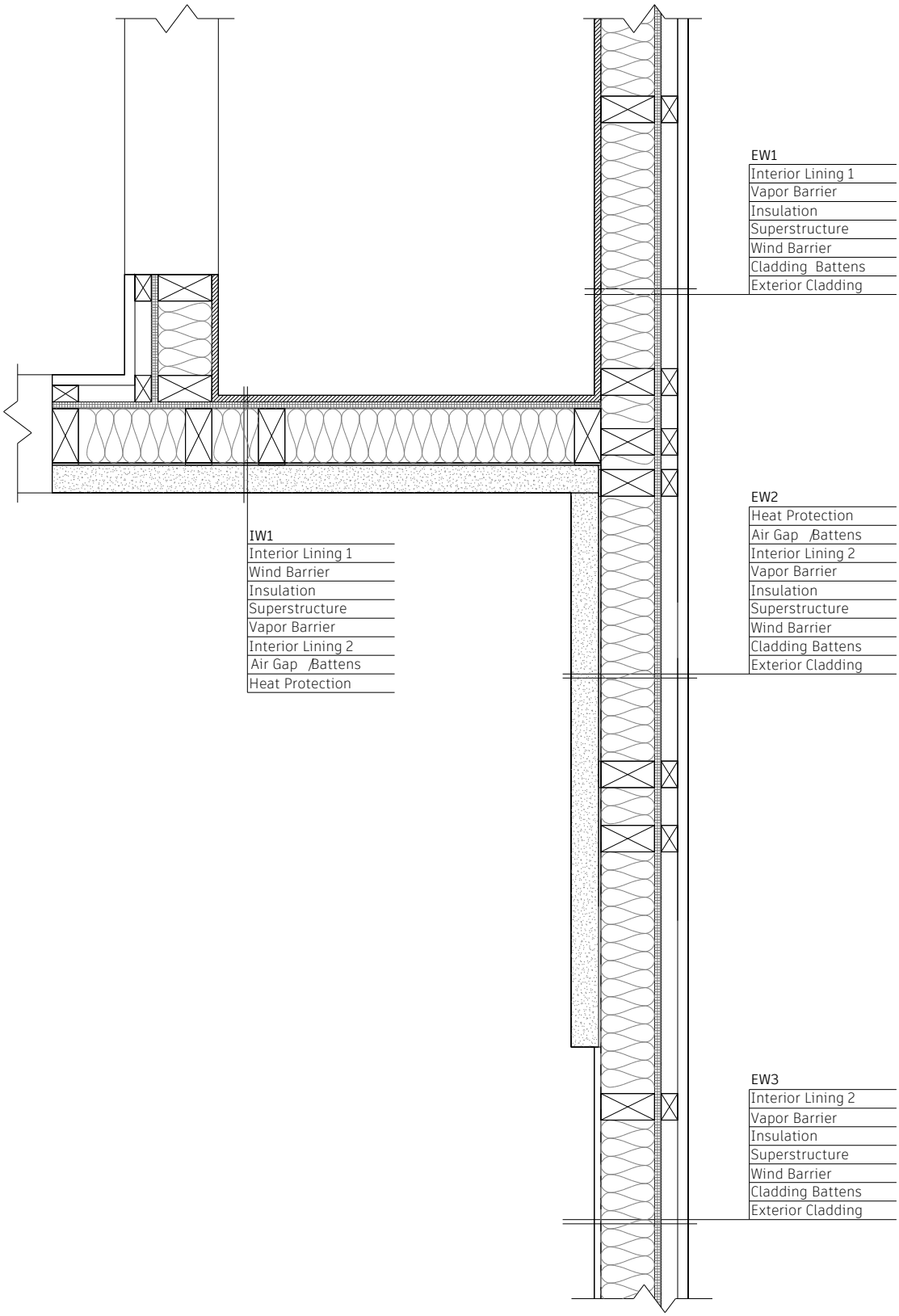


FIGURE 1.
Defenition of walls layers

following layers: interior lining 1, vapor barrier, wind barrier, superstructure and insulation, vapor barrier, interior lining 2 or air gap/battens, and heat protection. In this composition, the wall was erected at the construction site; however, there is no significant need to add a wind barrier to the structure. Therefore, this layer will be changed to another one for the calculations of subsequent cabins.

FLOORS

In the cabin, four types of floor construction can be distinguished, where three are located inside the premises and one outside. The first and the second types of floors are located inside the cabin. (Figure 2) They are identical except for the chosen superstructure - beams with a cross-section of 48 millimeters by 98 millimeters and 48 millimeters by 148 millimeters. Floors consist of the following layers: subfloor, insulation and superstructure, leveling underfloor, and interior floor.

The third type of the floor is located in the drying room and consists of a subfloor, insulation and superstructure, leveling underfloor, and waterproofing (Figure 3). This floor construction was used in the prototype; however, it was decided to use the fourth type of floor in the drying room for further implementation of the cabin.

The fourth type of floor is located outside the premises and is a terrace (Figure 3). The terrace consists of only one layer - terrace boards, located with gaps between each other to ensure the natural descent of dirt from the soles of the boots.

ROOF

There is only one roofing option in the project, covering the entire cabin. The roof consists of the following layers: waterproofing, cladding, air gap/railings, wind barrier, superstructure and insulation, roof vapor barrier, and interior ceiling (Figure 4). The part of the roof covering the terrace does not contain layers of insolation and vapor barrier, but otherwise is its continuation. When calculating the materials in this part of the roof, the insulation and the vapor barrier were not counted.

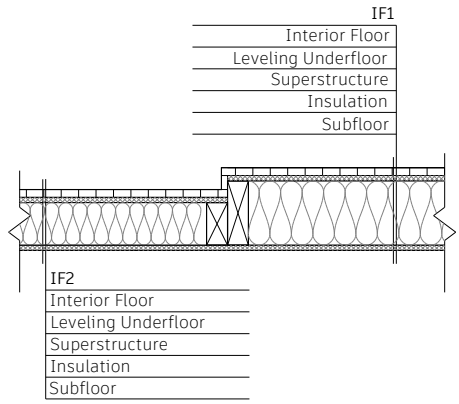


FIGURE 2. Defenition of floor layers

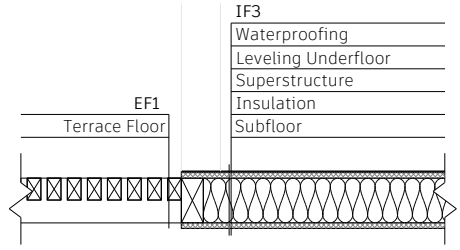


FIGURE 3. Defenition of floor layers

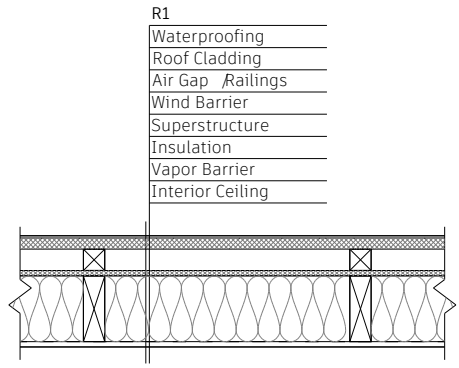


FIGURE 4. Defenition of roof layers

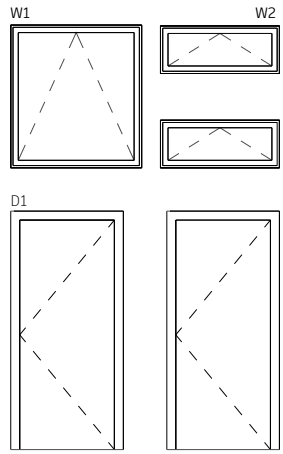


FIGURE 5. Defenition of doors and windows

WINDOWS AND DOORS

The project assumes using two external doors measuring 2 meters by 0.8 meters and three windows (Figure 5). Two windows have dimensions of 0.4 meters in height and 1 m in length; the third window has a height of 1.1 meters and a length of 1.2 meters.

DEFINITION OF MATERIALS

Once all the layers of the structural elements of the building were determined, work began on the selection of materials for the cabin, taking into account the previously described factors. Since not all pre-conceived materials were available at the time the prototype was built, some of them were replaced with available ones. Also, during the construction process, some mistakes were found in the design solutions and the choice of materials, which had not been resolved at the time of construction. Thus, in this thesis, two options for the selected materials will be considered: a list of materials used in the prototype and a modified list of materials based on the experience of building a prototype, with corrected shortcomings and some previously not possible to order materials.

PROTOTYPE'S MATERIALS

Let us look into the materials selected and used in the prototype based on the structural elements and layers. In total, 13 materials of various thicknesses and sizes and 3 elements were used to construct the cabin.

Pressure impregnated timber was chosen as the material for all structural elements, battens, railings and terrace boards (Tables 2, 3, 4, 5). The reasons for choosing this particular type of timber were its ubiquitous availability on the market in Bodø and the material's good resistance to weather damage. Thus, the initial focus in choosing the material for the superstructure was on the durability and availability of the material, which would allow the building to last longer without maintenance. Subsequently, this focus has been changed, which is described in the "Proposed Materials" sub-chapter.

Raw plywood sheets were used for the interior lining 1 of the EW1 and IW1 walls, measuring 1250 millimeters by 1250 millimeters and 12 millimeters thick (Table 3). The decision to use this material for the drying room was driven by the ubiquitous availability of the material in Bodø, its ability to add structural stiffness, reasonably good environmental performance, reusability after dismantling, and relative cheapness. Subsequently, the decision regarding this material was changed, which is described in the "Proposed Materials" sub-chapter.

Raw interior pine panels 120 millimeters high and 13 millimeters thick were used as interior lining 1 in walls EW2, EW3, IW1. The choice of this material was dictated by its aesthetically pleasing appearance, availability for purchase in Bodø, environmental characteristics, and the possibility of subsequent reuse as a material or fuel.

Hunton Intello Plus has been used as a vapor barrier layer in all cabin walls and in roof (Tables 3, 5). Hunton Intello Plus is a steam brake that replaces a vapor barrier and provides maximum protection for all types of insulation, especially wood fiber insulation, in ceilings, walls, and floors. The choice of this material was caused by its

Conctruction element	Type	Layer name	Selected material	Proposed material
Superstructure	ST1		Pressure impregnated timber, 48 mm * 98 mm	Structural timber of pine, 48 mm * 98 mm
	B1		Pressure impregnated timber, 48 mm * 98 mm	Structural timber of pine, 48 mm * 98 mm
	B2		Pressure impregnated timber, 48 mm * 148 mm	Structural timber of pine, 48 mm * 198 mm
	CB1		Pressure impregnated timber, 48 mm * 98 mm	Structural timber of pine, 48 mm * 98 mm

TABLE 2. Materials assigned to the superstructure

TABLE 3. Materials assigned to the walls

Conctruction element	Type	Layer name	Selected material	Proposed material
Exterior walls	EW1	Interior lining 1	Plywood sheets, 1250mm * 1250 mm, thickness 12mm	Interior pine pannels, 120mm * 13mm
		Vapor barrier	Hunton Intello Plus, 1500mm * 50000mm, thickness 0,2mm	Hunton Intello Plus, 1500mm * 50000mm, thickness 0,2mm
		Insulation	Hunton Nativo Trefiberisolasjon plate, 565mm * 1220mm, thickness 100mm	Hunton Nativo Trefiberisolasjon plate, 565mm * 1220mm, thickness 100mm
		Wind barrier	Hunton Vindett Plus, 1200mm * 2740 mm, thickness 12mm	Hunton Vindett Plus, 1200mm * 2740 mm, thickness 12mm
		Cladding battens	Pressure impregnated timber, 48 mm * 30 mm	Structural timber of pine, 48 mm * 30 mm
		Exterior cladding	Untreated pine cladding, 145mm * 16mm	Untreated pine core cladding, 173mm * 19mm
	EW2	Heat protection	Fliselim plaster board 1000mm * 1250 mm	Fliselim plaster board 1000mm * 1250 mm
		Heat protection battens	Pressure impregnated timber, 48 mm * 10 mm	Structural timber of pine, 48 mm * 10 mm
		Interior lining 2	Interior pine pannels, 120mm * 13mm	Interior pine pannels, 120mm * 13mm
		Vapor barrier	Hunton Intello Plus, 1500mm * 50000mm, thickness 0,2mm	Hunton Intello Plus, 1500mm * 50000mm, thickness 0,2mm
		Insulation	Rockwool I-PLATE A, 1200mm * 600 mm, thickness 100mm	Rockwool I-PLATE A, 1200mm * 600 mm, thickness 100mm
		Wind barrier	Hunton Vindett Plus, 1200mm * 2740 mm, thickness 12mm	Hunton Vindett Plus, 1200mm * 2740 mm, thickness 12mm
		Cladding battens	Pressure impregnated timber, 48 mm * 30 mm	Structural timber of pine, 48 mm * 30 mm
		Exterior cladding	Untreated pine cladding, 145mm * 16mm	Untreated pine core cladding, 173mm * 19mm
	EW3	Interior lining 2	Interior pine pannels, 120mm * 13mm	Interior pine pannels, 120mm * 13mm
		Vapor barrier	Hunton Intello Plus, 1500mm * 50000mm, thickness 0,2mm	Hunton Intello Plus, 1500mm * 50000mm, thickness 0,2mm
		Insulation	Hunton Nativo Trefiberisolasjon plate, 565mm * 1220mm, thickness 100mm	Hunton Nativo Trefiberisolasjon plate, 565mm * 1220mm, thickness 100mm
		Wind barrier	Hunton Vindett Plus, 1200mm * 2740 mm, thickness 12mm	Hunton Vindett Plus, 1200mm * 2740 mm, thickness 12mm
		Cladding battens	Pressure impregnated timber, 48 mm * 30 mm	Structural timber of pine, 48 mm * 30 mm
		Exterior cladding	Untreated pine cladding, 145mm * 16mm	Untreated pine core cladding, 173mm * 19mm
Interior walls	IW1	Interior lining 1	Plywood sheets, 1250mm * 1250 mm, thickness 12mm	Interior pine pannels, 120mm * 13mm
		Wind barrier	Hunton Vindett Plus, 1200mm * 2740 mm, thickness 12mm	Hunton Intello Plus, 1500mm * 50000mm, thickness 0,2mm
		Insulation	Hunton Nativo Trefiberisolasjon plate, 565mm * 1220mm, thickness 100mm	Rockwool I-PLATE A, 1200mm * 600 mm, thickness 100mm
		Vapor barrier	Hunton Intello Plus, 1500mm * 50000mm, thickness 0,2mm	Hunton Intello Plus, 1500mm * 50000mm, thickness 0,2mm
		Interior lining 2	Interior pine pannels, 120mm * 13mm	Interior pine pannels, 120mm * 13mm
		Heat protection battens	Pressure impregnated timber, 48 mm * 10 mm	Structural timber of pine, 48 mm * 10 mm
		Heat protection	Fliselim plaster board 1000mm * 1250 mm	Fliselim plaster board 1000mm * 1250 mm

TABLE 4. Materials assigned to the roof

Conctruction element	Type	Layer name	Selected material	Proposed material
Roof	R1	Waterproofing	Roof overlay Self-builder 3 °, 1000 mm * 7000 mm, thickness 3 mm	Roof overlay Self-builder 3 °, 1000 mm * 7000 mm, thickness 3 mm
		Roof cladding	OSB Plate, 2400mm * 1220mm, thickness 24mm	Structural timber of pine, 198 mm * 36 mm
		Roof railings	Pressure impregnated timber, 48 mm * 48 mm	Structural timber of pine, 48 mm * 48 mm
		Wind barrier	OSB Plate, 2400mm * 1220mm, thickness 12mm	Hunton Undertak, 2420mm * 595mm, thickness 18mm
		Insulation	Hunton Nativo Trefiberisolasjon plate, 565mm * 1220mm, thickness 150mm	Hunton Nativo Trefiberisolasjon plate, 565mm * 1220mm, thickness 150mm
		Vapor barrier	Hunton Intello Plus, 1500mm * 50000mm, thickness 0,2mm	Hunton Intello Plus, 1500mm * 50000mm, thickness 0,2mm
		Interior ceiling	Interior pine pannels, 120mm * 13mm	Interior pine pannels, 120mm * 13mm

TABLE 5. Materials assigned to the floors

Conctruction element	Type	Layer name	Selected material	Proposed material
Floors	IF1	Interior floor	Oak Recycled Parquete	Pergo Lofoten Natural Oak Parquete
		Leveling underfloor	OSB Plate, 2400mm * 1220mm, thickness 12mm	Hunton Silencio Parkettunderlag, 600mm * 1800mm, thickness 12mm
		Insulation	Hunton Nativo Trefiberisolasjon plate, 565mm * 1220mm, thickness 150mm	Hunton Nativo Trefiberisolasjon plate, 565mm * 1220mm, thickness 200mm
		Subfloor	OSB Plate, 2400mm * 1220mm, thickness 12mm	Structural timber of pine, 198 mm * 36 mm
	IF2	Heat protection	Temprered glass plate, 1000mm * 1000mm, thickness 4mm	Temprered glass plate, 1000mm * 1000mm, thickness 4mm
		Interior floor	Oak Recycled Parquete	Pergo Lofoten Natural Oak Parquete
		Leveling underfloor	OSB Plate, 2400mm * 1220mm, thickness 12mm	Hunton Silencio Parkettunderlag, 600mm * 1800mm, thickness 12mm
		Insulation	Hunton Nativo Trefiberisolasjon plate, 565mm * 1220mm, thickness 100mm	Hunton Nativo Trefiberisolasjon plate, 565mm * 1220mm, thickness 100mm
		Subfloor	OSB Plate, 2400mm * 1220mm, thickness 12mm	Structural timber of pine, 198 mm * 36 mm
	IF3	Waterproofing	Roof overlay Self-builder 3 °, 1000 mm * 7000 mm, thickness 3 mm	Not necessary, remove
		Leveling underfloor	OSB Plate, 2400mm * 1220mm, thickness 12mm	Not necessary, remove
		Insulation	Hunton Nativo Trefiberisolasjon plate, 565mm * 1220mm, thickness 100mm	Not necessary, remove
		Subfloor	OSB Plate, 2400mm * 1220mm, thickness 120mm	Structural timber of pine, 48 mm * 30 mm
	EF1	Terrace floor	Pressure impregnated timber, 48 mm * 30 mm	Structural timber of pine, 48 mm * 30 mm

TABLE 6. Materials assigned to the windows and doors

Conctruction element	Type	Layer name	Selected material	Proposed material
Windows	W1		NorDan small window top hinged, white wooden frame, 1000mm * 400mm	NorDan small window top hinged, white wooden frame, 1000mm * 400mm
	W2		NorDan Villa top swingwith valve, white wooden frame, 1100 mm * 1200 mm	NorDan Villa top swingwith valve, white wooden frame, 1100 mm * 1200 mm
Doors	D1		Opus Ytterdør, white, 800mm * 2000mm	Opus Ytterdør, white, 800mm * 2000mm

versatility of use, not in the composition of walls only but in other structural elements. According to the manufacturer, it provides ideal protection against unwanted moisture and mold, which is a critical condition for extending the cabin's life. The material was also recommended by supervisor Pasi Aalto, who has extensive experience in constructing micro houses and cabins.

The requests of the DNT largely dictated the choice of thermal insulation for the cabin. Representatives of the organization shared their practical observations on the content of the cabins located in the wild and bad experiences with insulating materials such as GLAVA glass wool. The problem is that rodents actively use this isolation as their dens and shelter. Another practical advice was shared with us by supervisor Pasi Aalto, who noticed glass wool insulation slipping down in a wall structure while transporting one of his micro houses. Thus, the insulation choice was made in favor of Hunton Nativo Wood Fiber Insulation. This insulation is based on a renewable raw material from Norway, and it stores carbon throughout the product's life cycle. The material is very light yet dense, can be reused, was available in the vicinity of Bodø at the time of construction, and has good thermal and environmental characteristics, has SINTEF Technical Approval. There was no confirmation or refutation that rodents would not be able to use this material for nesting. Although, the supervisors and the customer support the decision to use this material and test it in practice. Thus Hunton Nativo Wood Fiber Insulation 98 millimeters and 148 millimeters thick is used in EW1, EW3, IW1 walls; IF1, IF2, IF3 floors; R1 roof (Tables 3, 4, 5).

A different material was chosen as the thermal insulation of the EW2 wall (Table 3). This material is a ROCKWOOL stone wool insulation. The reason for choosing a different material for this wall was the installation of a wood-burning stove and pipe running through that wall. To ensure the fire safety of a wall, a material that had a low ability to ignite from touching the double walls of the pipe was needed. A new roll of this insulation with thickness of 98 millimeters was given to us free of charge along with the purchase of a used window from the owner of one of the renovation buildings in Bodø.

Hunton Vindett Plus sheets, 1200 millimeters by 2740 millimeters and 12 millimeters thick, were used as the material for the wind barrier layer in all walls (Table 3). This material was chosen mainly for its lightness compared to other materials such as OSB used as a wind barrier. The material consists of wood fiber, which is produced from renewable raw materials. The material has SINTEF Technical Approval and excellent insulating and moisture-absorbing properties. However, Hunton Vindett Plus can only be used for walls, floors and roof need other materials to act as a wind barrier.

Thus the wind barrier layers in the roof R1 and floors IF1, IF2, IF3 (where the wind barrier also serves as a subfloor) are represented by OSB Plates, 2400 millimeters by 1220 millimeters in size, with a thickness of 12 millimeters (Tables 4, 5). OSB plates are also used as leveling underfloor in IF1, IF2, IF3 floors, as well as a roof cladding material in R1 roof (Tables 4, 5). The decision to use OSB for many functions was due to the inability to order previously selected materials. The choice of this material entailed many problems related to the characteristics of the material that arose during the construction, namely: its instability to moisture and its inability to function as a subfloor layer for a long time, which entailed the application of additional layers of surface treatment; high weight and insufficient bending strength of the material, which affected both the number of layers of the material used in the roof cladding R1 layer and the direction of the future interior floor material in the floors IF1, IF2; low potential for reuse and short life span. After construction, all the shortcomings of using this material were identified, and an attempt to completely replace OSB with other materials in future cabins was made, described in the "Proposed Materials" sub-chapter.

For the exterior cladding of all exterior walls, raw pine boards 145 millimeters high and 16 millimeters thick were used (Table 3). The choice of this material was also dictated by the impossibility of ordering the previously selected material, but this change did not affect the quality of the project. Pine boards have good environmental characteristics and can be reused as a material or fuel in the future. It was decided to cover the material with a protective composition in the future to extend the life span of the cladding. In addition, measures have been taken when installing the lower cladding panels, facilitating the subsequent replacement of the lower parts most susceptible to damage.

Mataki Roof overlay Self-builder 3°, 1000 millimeters by 7000 millimeters, and 3 millimeters thick, was used to protect the R1 roof and IF3 floor in the drying room from water influence (Tables 4, 5). Mataki Selvbygger 3 is a single-layer self-adhesive roof coating consisting of SBS asphalt and a strong fiberglass-reinforced polyester trunk. This material was selected due to its lightness compared to other roofing materials and availability on the local market.

For interior flooring, IF1 and IF2, previously used oak parquet with a thickness of 18 millimeters was found (Table 5). The choice of hardwood parquet for the cabin project is dictated by its durability, aesthetic beauty, and the possibility of purchasing a used one. The thesis team carefully prepared the parquet for a new circle of life in the NTNU wooden workshop.

Fliselim plasterboard with dimensions 1000 millimeters * 1250 millimeters, the thickness of 50 millimeters, was used as a heatproof layer for EW2, IW1 walls (Table 3). A tempered glass plate, dimensions 1000mm * 1000mm, thickness 4mm, was used as the heatproof layer of the IF2 floor (Table 5). The choice of plasterboard was dictated by fire regulations for the area near the heating element. Covering the floor around the woodstove with glass is imposed by the aesthetic appeal of the material, its durability, and the possibility of further reuse.

An attempt was made to find previously used elements for the selected window and door elements. (Table 6) The thesis team was able to find previously used windows of the required size in Bodø. These are NorDan windows with wooden frames and a double layer of glazing. For two windows with sizes of 1000 millimeters by 400 millimeters, a model of the NorDan small top-hinged window was used. For a window with a size of 1100 millimeters by 1200 millimeters, a model of the NorDan Villa top swing window with a valve was used. Used door elements could not be found in Trondheim or Bodø, so the project used two new 2000 millimeters by 800 millimeters wooden exterior doors from Opus Ytterdør.

PROPOSED MATERIALS

After the experience of building a prototype, shortcomings and mistakes in the choice of design solutions and materials were discovered. Since the project may become massive, a new sheet with materials was proposed, where the experience of building

Material used in prototype	Proposed material	Reason of change
Plywood sheets, 1250mm * 1250 mm, thickness 12mm	Interior pine pannels, 120mm * 13mm	Better in terms of future re-use and re-cycle
Pressure impregnated timber, all dimentions	Structural timber of pine, all dimentions	Better in terms of future re-use and re-cycle
Untreated pine cladding, 145mm * 16mm	Untreated pine core cladding, 173mm * 19mm	Better qualities in durability
Hunton Vindett Plus, 1200mm * 2740 mm,	Hunton Intello Plus, 1500mm * 50000mm	Incorrect layer
Hunton Nativo Trefiberisolasjon plate, 565mm * 1220mm, thickness	Rockwool I-PLATE A, 1200mm * 600 mm, thickness 100mm	Better heat protection in the stove area
Oak Recycled Parquete	Pergo Lofoten Natural Oak Parquete	Not available to buy again
OSB Plate, 2400mm * 1220mm, thickness 12mm	Hunton Silencio Parkettunderlag, 600mm * 1800mm, thickness	Weight
Roof overlay Self-builder 3 °, 1000 mm * 7000 mm, thickness 3 mm		Not necessary, remove
OSB Plate, 2400mm * 1220mm, thickness 12mm		Not necessary, remove
Hunton Nativo Trefiberisolasjon plate, 565mm * 1220mm, thickness		Not necessary, remove
OSB Plate, 2400mm * 1220mm, thickness 120mm	Structural timber of pine, 48 mm * 30 mm	Better in terms of future re-use and re-cycle
OSB Plate, 2400mm * 1220mm, thickness 24mm	Structural timber of pine, 198 mm * 36 mm	Better in terms of future re-use and re-cycle
OSB Plate, 2400mm * 1220mm, thickness 12mm	Hunton Undertak, 2420mm * 595mm,	Weight

TABLE 7. Reasons of material change

a prototype was taken into account, and errors were corrected (Table 7).

Pressure impregnated timber for all structural layers and elements has been replaced with structural timber of pine. This material was prioritized incorrectly, and instead of durability, the customer would have preferred material with good environmental characteristics that could be reused as a material or fuel.

Raw plywood sheets in the drying room are proposed to be replaced with the same interior material as in the cabin. This decision was made due to the great potential to reuse raw interior panels as material or fuel in the future.

It is proposed to change the thermal insulation material in the IW1 inner wall from Hunton Nativo Wood Fiber Insulation to ROCKWOOL stone wool insulation. This change was caused by the concern for the inner wall located near the woodstove. By changing the insolation material to a more resistant to heat, possible risks of fire in the cabin can be prevented.

The Hunton Vindett Plus layer, located in the inner wall of IW1 as a wind barrier, is unnecessary and can be removed from subsequent cabins. However, an additional vapor barrier layer is needed in its place, which will be embodied by the Hunton Intello Plus.

It was decided to change the widespread use of OSB sheets in the project since the material does not correspond to its proposed functions. Thus, the material of the wind barrier layer in the R1 roof was changed to Hunton Undertak sheets, with dimensions of 2420 millimeters by 595 millimeters and a thickness of 18 millimeters. The use of this material was planned in the original concept due to its lightness, but it was not available for order at the time of construction. The material is an analogue of Hunton Vindett Plus and has the same characteristics but is used for roofing. For leveling underfloor layers in floors IF1 and IF2, the Hunton Silencio Parkettunderlag, 600 millimeters by 1800 millimeters and 12 millimeters thick, was supposed to be used. This material is a wood fiber board, which is designed for laying under parquet; it is lightweight and, at the same time, resistant to bending. For the floor of the drying room, it is proposed to change the design from IF3 to EF1 completely. This decision was made in order to provide a better supply of fresh air to the room and avoid the formation of moisture. For roof cladding layer in the R1 roof and subfloor layers in the IF1 and IF2 floors, it is proposed to replace OSB sheets with pine boards with a cross-section of 198 millimeters by 38 millimeters. This solution will eliminate the need for frequent replacement or additional processing of these materials. Also, pine boards are more likely to be reused, which is not the case with OSB sheets. As a material for exterior cladding, instead of the one used in the prototype, it is proposed to use the previously selected option - untreated pine-core cladding, which was not available for order when the prototype was built. Measuring 173mm by 19mm, this material has similar characteristics to used cladding but is better quality and more resistant to aging.

Finally, instead of the parquet used in the prototype, its new counterpart is proposed - Pergo Lofoten Natural Oak Parquete. This happened because the material used was a single find and cannot be used in all subsequent cabins.

CIRCULARITY OF MATERIALS

Since, during the construction of the prototype, it was possible to introduce some previously used materials and elements, it was decided to check the limits of using reused materials in the project after adjusting them. Most of the proposed materials can be reused, which is a good prospect for implementing the concept of a circular cabin (Table 8). In order to check how environmentally beneficial the reuse of materials in this project would be, an additional life-cycle analysis of the cabin was carried out, where previously used materials and elements would be implemented to their maximum.

TABLE 8. Opportunities to find and implement re-used materials in the project

Conctruction element	Type	Layer name	Selected material	Proposed material
Exterior walls	EW1	Interior lining 1	Plywood sheets, 1250mm * 1250 mm, thickness 12mm	Interior pine pannels, 120mm * 13mm
		Insulation	Hunton Nativo Trefiberisolasjon plate, 565mm * 1220mm, thickness 100mm	Hunton Nativo Trefiberisolasjon plate, 565mm * 1220mm, thickness 100mm
		Cladding battens	Pressure impregnated timber, 48 mm * 30 mm	Structural timber of pine, 48 mm * 30 mm
		Exterior cladding	Untreated pine cladding, 145mm * 16mm	Untreated pine core cladding, 173mm * 19mm
	EW2	Heat protection	Fliselim plaster board 1000mm * 1250 mm	Fliselim plaster board 1000mm * 1250 mm
		Heat protection battens	Pressure impregnated timber, 48 mm * 10 mm	Structural timber of pine, 48 mm * 10 mm
		Interior lining 2	Interior pine pannels, 120mm * 13mm	Interior pine pannels, 120mm * 13mm
		Insulation	Rockwool I-PLATE A, 1200mm * 600 mm, thickness 100mm	Rockwool I-PLATE A, 1200mm * 600 mm, thickness 100mm
		Cladding battens	Pressure impregnated timber, 48 mm * 30 mm	Structural timber of pine, 48 mm * 30 mm
		Exterior cladding	Untreated pine cladding, 145mm * 16mm	Untreated pine core cladding, 173mm * 19mm
	EW3	Interior lining 2	Interior pine pannels, 120mm * 13mm	Interior pine pannels, 120mm * 13mm
		Insulation	Hunton Nativo Trefiberisolasjon plate, 565mm * 1220mm, thickness 100mm	Hunton Nativo Trefiberisolasjon plate, 565mm * 1220mm, thickness 100mm
		Cladding battens	Pressure impregnated timber, 48 mm * 30 mm	Structural timber of pine, 48 mm * 30 mm
		Exterior cladding	Untreated pine cladding, 145mm * 16mm	Untreated pine core cladding, 173mm * 19mm
Interior walls	IW1	Interior lining 1	Plywood sheets, 1250mm * 1250 mm, thickness 12mm	Interior pine pannels, 120mm * 13mm
		Insulation	Hunton Nativo Trefiberisolasjon plate, 565mm * 1220mm, thickness 100mm	Rockwool I-PLATE A, 1200mm * 600 mm, thickness 100mm
		Interior lining 2	Interior pine pannels, 120mm * 13mm	Interior pine pannels, 120mm * 13mm
		Heat protection battens	Pressure impregnated timber, 48 mm * 10 mm	Structural timber of pine, 48 mm * 10 mm
		Heat protection	Fliselim plaster board 1000mm * 1250 mm	Fliselim plaster board 1000mm * 1250 mm
Superstructure	ST1		Pressure impregnated timber, 48 mm * 98 mm	Structural timber of pine, 48 mm * 98 mm
	B1		Pressure impregnated timber, 48 mm * 98 mm	Structural timber of pine, 48 mm * 98 mm
	B2		Pressure impregnated timber, 48 mm * 148 mm	Structural timber of pine, 48 mm * 198 mm
	CB1		Pressure impregnated timber, 48 mm * 98 mm	Structural timber of pine, 48 mm * 98 mm
Floors	IF1	Interior floor	Oak Recycled Parquete	Pergo Lofoten Natural Oak Parquete
		Insulation	Hunton Nativo Trefiberisolasjon plate, 565mm * 1220mm, thickness 150mm	Hunton Nativo Trefiberisolasjon plate, 565mm * 1220mm, thickness 200mm
		Subfloor	OSB Plate, 2400mm * 1220mm, thickness 120mm	Structural timber of pine, 198 mm * 36 mm
	IF2	Heat protection	Temprered glass plate, 1000mm * 1000mm, thickness 4mm	Temprered glass plate, 1000mm * 1000mm, thickness 4mm
		Interior floor	Oak Recycled Parquete	Pergo Lofoten Natural Oak Parquete
		Insulation	Hunton Nativo Trefiberisolasjon plate, 565mm * 1220mm, thickness 100mm	Hunton Nativo Trefiberisolasjon plate, 565mm * 1220mm, thickness 100mm

TABLE 8. Opportunities to find and implement re-used materials in the project (continued)

Conctruction element	Type	Layer name	Selected material	Proposed material
Floors		Subfloor	OSB Plate, 2400mm * 1220mm, thickness 120mm	Structural timber of pine, 198 mm * 36 mm
	IF3	Subfloor	OSB Plate, 2400mm * 1220mm, thickness 120mm	Structural timber of pine, 48 mm * 30 mm
	EF1	Terrace floor	Pressure impregnated timber, 48 mm * 30 mm	Structural timber of pine, 48 mm * 30 mm
Roof	R1	Roof cladding	OSB Plate, 2400mm * 1220mm, thickness 240mm	Structural timber of pine, 198 mm * 36 mm
		Roof railings	Pressure impregnated timber, 48 mm * 48 mm	Structural timber of pine, 48 mm * 48 mm
		Insulation	Hunton Nativo Trefiberisolasjon plate, 565mm * 1220mm, thickness 150mm	Hunton Nativo Trefiberisolasjon plate, 565mm * 1220mm, thickness 150mm
		Interior ceiling	Interior pine pannels, 120mm * 13mm	Interior pine pannels, 120mm * 13mm
Windows	W1		NorDan small window top hinged, white wooden frame, 1000mm * 400mm	NorDan small window top hinged, white wooden frame, 1000mm * 400mm
	W2		NorDan Villa top swingwith valve, white wooden frame, 1100 mm * 1200 mm	NorDan Villa top swingwith valve, white wooden frame, 1100 mm * 1200 mm
Doors	D1		Opus Ytterdør, white, 800mm * 2000mm	Opus Ytterdør, white, 800mm * 2000mm

III. WEIGHT

WEIGHT OF PROTOTYPE

A critical condition for cabin design was its weight. Since the initial project is not stationary and requires further transportation, the weight and quantity of each material are of great importance. The cabin weight limit is 3.6 tons, which is a consequence of the helicopter's carrying capacity. Volumes of all materials were identified, and densities of all materials were found. By simple mathematical calculations, it was possible to obtain the approximate weight of all cabin's construction elements and the total weight of the building (Table 9). Thus, the weight of a prototype is 3.34 tons, which is matching with the weight requirements.

WEIGHT OF CABIN WITH PROPOSED MATERIALS

Since an improved cabin design with modified materials was proposed after the prototype was built, the weight of the building had to be calculated and compared with the weight of the prototype. The same method was used for the calculation, with the volumes of materials and their density (Table 10). As a result of calculations, the weight of the building with the proposed materials would be 2.96 tons, which is almost 380 kilograms less than the weight of the prototype (Figure 6). Such a difference in weight is significant, which allows us to conclude that the decision to change some materials in the cabin is justified for transportation purposes.

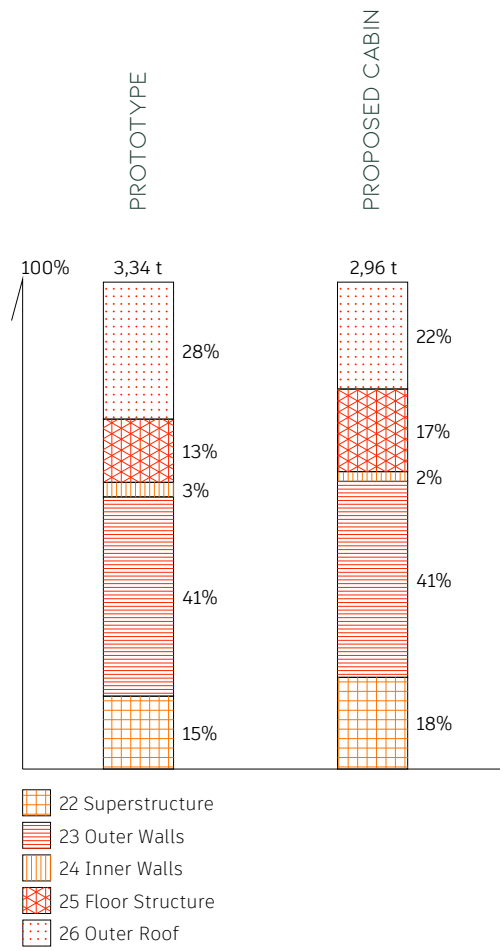


FIGURE 6. Weight of prototype with implemented and proposed materials

TABLE 9. Weight of prototype

Building Element	Product	Amount	Unit	Density (weight kg/ m3 or m2)	Weight (kg)
22 Superstructure	Pressure impregnated timber, 48 mm * 98 mm	0,71	m³	480	340,8
	Pressure impregnated timber, 48 mm * 148 mm	0,36	m³	480	172,8
					Total = 513,6 kg
23 Outher Walls	Plywood sheets, 1250mm * 1250 mm, thickness 12mm	0,042	m³	600	25,2
	Interior pine pannels, 120mm * 13mm	0,42	m³	435	182,7
	Hunton Intello Plus, 1500mm * 50000mm, thickness 0,2mm	38,28	m²	0,12	4,5936
	Hunton Vindett Plus, 1200mm * 2740 mm, thickness 12mm	0,459	m³	235	107,865
	Hunton Nativo Trefiberisolasjon plate, 565mm * 1220mm, thickness 100mm	3,828	m³	50	191,4
	Rockwool I-PLATE A, 1200mm * 600 mm, thickness 100mm	0,204	m³	60	12,24
	Pressure impregnated timber, 48 mm * 10 mm	0,0024	m³	480	1,152
	Pressure impregnated timber, 48 mm * 30 mm	0,151	m³	480	72,48
	Untreated pine cladding, 145mm * 16mm	1,09	m³	480	523,2
	Fliselim plaster board 1000mm * 1250 mm	0,062	m³	700	43,4
	NorDan small window top hinged, white wooden frame, 1000mm * 400mm	2	pc	25	50
	NorDan Villa top swingwith valve, white wooden frame, 1100 mm * 1200 mm	1	pc	85	85
	Opus Ytterdør, white, 800mm * 2000mm	2	pc	35	70
					Total = 1369,2 kg
24 Inner Walls	Plywood sheets, 1250mm * 1250 mm, thickness 12mm	0,024	m³	600	14,4
	Interior pine pannels, 120mm * 13mm	0,012	m³	435	5,22
	Hunton Intello Plus, 1500mm * 50000mm, thickness 0,2mm	4,08	m²	0,12	0,4896
	Hunton Vindett Plus, 1200mm * 2740 mm, thickness 12mm	0,024	m³	235	5,64
	Hunton Nativo Trefiberisolasjon plate, 565mm * 1220mm, thickness 100mm	0,204	m³	50	10,2
	Pressure impregnated timber, 48 mm * 10 mm	0,0024	m³	480	1,152
	Fliselim plaster board 1000mm * 1250 mm	0,062	m³	700	43,4
					Total = 80,5 kg
25 Floor Structure	Temprered glass plate, 1000mm * 1000mm, thickness 4mm	0,004	m³	2520	10,08
	Oak Recycled Parquete	0,216	m³	500	108
	OSB Plate, 2400mm * 1220mm, thickness 12mm	0,36	m³	600	216
	Hunton Nativo Trefiberisolasjon plate, 565mm * 1220mm, thickness 100mm	0,41	m³	50	20,5
	Hunton Nativo Trefiberisolasjon plate, 565mm * 1220mm, thickness 150mm	1,185	m³	50	59,25
	Roof overlay Self-builder 3 °, 1000 mm * 7000 mm, thickness 3 mm	1,3	m²	4,5	5,85
	Pressure impregnated timber, 48 mm * 30 mm	0,027	m³	480	12,96
					Total = 432,6 kg
26 Outer Roof	Roof overlay Self-builder 3 °, 1000 mm * 7000 mm, thickness 3 mm	16,5	m²	4,5	74,25
	OSB Plate, 2400mm * 1220mm, thickness 12mm	1,08	m³	600	648
	Pressure impregnated timber, 48 mm * 48 mm	0,067	m³	480	32,16
	Hunton Nativo Trefiberisolasjon plate, 565mm * 1220mm, thickness 150mm	2,1	m³	50	105
	Hunton Intello Plus, 1500mm * 50000mm, thickness 0,2mm	15	m²	0,12	1,8
	Interior pine pannels, 120mm * 13mm	0,205	m³	435	89,175
					Total = 950,38 kg

Total weight of the building = 3346,28 kg = 3,34 t

TABLE 10. Weight of cabin with proposed materials

Building Element	Product	Amount	Unit	Density (weight kg/ m3 or m2) or weight of element (kg)	Weight (kg)
22 Superstructure	Structural timber of pine, 48 mm * 98 mm	0,71	m³	480	340,8
	Structural timber of pine, 48 mm * 148 mm	0,148	m³	480	71,04
	Structural timber of pine, 48 mm * 198 mm	0,279	m³	480	133,92
					Total = 545,76 kg
23 Outher Walls	Interior pine pannels, 120mm * 13mm	0,558	m³	435	242,73
	Hunton Intello Plus, 1500mm * 50000mm, thickness 0,2mm	38,28	m²	0,12	4,5936
	Hunton Vindett Plus, 1200mm * 2740 mm, thickness 12mm	0,459	m³	235	107,865
	Hunton Nativo Trefiberisolasjon plate, 565mm * 1220mm, thickness 100mm	3,828	m³	50	191,4
	Rockwool I-PLATE A, 1200mm * 600 mm, thickness 100mm	0,204	m³	60	12,24
	Structural timber of pine, 48 mm * 10 mm	0,0024	m³	480	1,152
	Structural timber of pine, 48 mm * 30 mm	0,151	m³	480	72,48
	Untreated pine core cladding, 173mm * 19mm	0,69	m³	480	331,2
	Fliselim plaster board 1000mm * 1250 mm	0,062	m³	700	43,4
	NorDan small window top hinged, white wooden frame, 1000mm * 400mm	2	pc	25	50
	NorDan Villa top swingwith valve, white wooden frame, 1100 mm * 1200 mm	1	pc	85	85
	Opus Ytterdør, white, 800mm * 2000mm	2	pc	35	70
					Total = 1212,1 kg
24 Inner Walls	Interior pine pannels, 120mm * 13mm	0,024	m³	435	10,44
	Hunton Intello Plus, 1500mm * 50000mm, thickness 0,2mm	4,08	m²	0,12	0,4896
	Rockwool I-PLATE A, 1200mm * 600 mm, thickness 100mm	0,204	m³	50	10,2
	Structural timber of pine, 48 mm * 10 mm	0,0024	m³	480	1,152
	Fliselim plaster board 1000mm * 1250 mm	0,062	m³	700	43,4
					Total = 65,682 kg
25 Floor Structure	Temprered glass plate, 1000mm * 1000mm, thickness 4mm	0,004	m³	2520	10,08
	Pergo Lofoten Natural Oak Parquete	0,216	m³	500	108
	Hunton Silencio Parkettunderlag, 600mm * 1800mm, thickness 12mm	0,144	m³	280	40,32
	Structural timber of pine, 198 mm * 36 mm	0,449	m³	480	215,52
	Hunton Nativo Trefiberisolasjon plate, 565mm * 1220mm, thickness 100mm	0,41	m³	50	20,5
	Hunton Nativo Trefiberisolasjon plate, 565mm * 1220mm, thickness 200mm	1,58	m³	50	79
	Structural timber of pine, 48 mm * 30 mm	0,056	m³	480	26,88
					Total = 500,3 kg
26 Outer Roof	Roof overlay Self-builder 3 °, 1000 mm * 7000 mm, thickness 3 mm	16,5	m²	4,5	74,25
	Structural timber of pine, 198 mm * 36 mm	0,598	m³	480	287,04
	Structural timber of pine, 48 mm * 48 mm	0,0677	m³	480	32,496
	Hunton Nativo Trefiberisolasjon plate, 565mm * 1220mm, thickness 150mm	1,8	m³	50	90
	Hunton Undertak, 2420mm * 595mm, thickness 18mm	0,27	m³	260	70,2
	Hunton Intello Plus, 1500mm * 50000mm, thickness 0,2mm	15	m²	0,12	1,8
	Interior pine pannels, 120mm * 13mm	0,205	m³	435	89,175
					Total = 644,96 kg

Total weight of the building = 2968,8 kg = 2,96 t

IV. LIFE-CYCLE ANALYSIS

GOALS AND SCOPE OF ASSESMENT

The environmental impact in terms of greenhouse gas emissions of the same cabin with different materials is calculated in this chapter. The calculated prototype cabin and its analogues have a gross floor area of 10 square meters and are new designs with the reference time of the building's life span of 60 years. The cabins are separate structures that are not connected to water and electricity networks. The system boundary includes the production stage (A1-A3) of the building's materials and the construction process stage (A4-A5). Thus, the environmental impact in terms of CO2eq emissions was calculated from 'cradle to site' and includes the emissions from a supply of raw materials, the transportation of them to the manufacturer, the manufacturing process for the final delivered product, transportation of materials from the manufacture to the building site and construction process (Table 11). Such systems boundaries were chosen since these manipulations were performed during the construction of the prototype.

INVENTORY ANALYSIS AND IMPACT OF ASSESMENT

To calculate the amount of materials used, numbers from the BIM model in the Revit program and the numbers from stores invoices were taken (Appendices). The scope of assessment across the building systems includes partially structure systems, entirely exterior systems, and partially interior systems (Table 12). Other systems are not included into the calculation due to the technical characteristics of the cabin. The One-Click LCA program and the EPD of selected materials were used to calculate the LCA of the cabin prototype and its proposed analogues. A5-construction process stage was manually calculated based on the demonstrative experience of building a prototype. Since the cabin is not connected to the electricity grid and is not intended to generate its own energy, the value and reference of GHG emissions coming from the electricity grid are not relevant in this study.

A1-A3 Product Stage			A4-A5 Construction process stage		B1-B7 Use stage						C1-C4 End of life stage			
A1- Raw material supply	A2 -Transport	A3 - Manufacturing	A4 - Transport	A5 - Construction process	B1 - Use	B2 - Maintenance	B3 - Repair	B4 - Replacement	B5 - Refurbishment		C1 - De-construction, demolition	C2 - Transport	C3 - Waste processing	C4 - Disposal
					B6 - Operational energy use									
					B7 - Operational water use									

TABLE 11. System boundaries

	Structure			Exterior				Interior						Systems						
Building systems	Foundation	Substructure	Superstructure	Walls	Roofs	Windows/ glazing	Doors	Walls	Ceilings	Floors	Finishes	Doors	Furniture	Mechanical	Electrical	Plumbing	Conveyance	Specialty	Other Contents

TABLE 12. Scope of assessment across building systems

EMISSIONS FROM CRADLE TO SITE (A1–A5)

When calculating emissions from cradle to site (A1-A5), one cabin's design was considered with three different sets of materials: with materials and elements used in the prototype; with materials adjusted after construction, where all materials and elements would be brand new; and with adjusted materials, where the maximum possible number of materials and elements would be re-used. The results obtained are evaluated in comparison at the end of the chapter.

EMISSIONS FROM MATERIALS

To calculate the A1-A3 stages of the production of the necessary materials, the One-Click LCA software was used, where three variants of the studied cabins were created. The EPDs of the selected materials were used as data resources if they were available. If the information could not be found for any of the selected materials, baseline values from the One-Click LCA or EPDs of the most similar materials were used in the calculation.

CALCULATIONS FOR CABIN PROTOTYPE

Calculations for the prototype showed that emissions from the production of materials are responsible for 515.7 $kgCO_{2eq}$, where biogenic carbon storage would be 3723.5 $kgCO_{2eq\ bio}$ (Table 13). The most significant embodied emissions per building component are in the outer wall structures (52%), the least - in the inner wall structure (4%) (Figure 7). The largest amount of embodied emissions from materials had been detected in Hunton Nativo Trefiberisolasjon plate thermal insulation (23%), the smallest- in Plywood sheets (1%) and Tempered glass plate (2%) (Figure 8). The proportions of the influence of other materials are approximately equal and vary from 3% to 15%.

CALCULATIONS FOR CABIN WITHOUT CIRCULAR MATERIALS

Calculations for the cabin with updated materials demonstrated that emissions from materials production are responsible for 834.9 $kgCO_{2eq}$, whereas biogenic carbon storage would be 4632.46 $kgCO_{2eq\ bio}$ (Table 14). This is almost 300 $kgCO_{2eq}$ more emissions from materials than in the prototype since reused materials were not used in the calculations. The most significant embodied emissions per building component are in the outer wall structures (55%), the least - in the superstructure (3%), and in the inner wall structure (3%) (Figure 9). The largest amount of embodied emissions from materials had been detected in Hunton Nativo Trefiberisolasjon plate thermal insulation (14%), which is almost comparable to emissions from NorDan window 1 (12%) and Pergo Lofoten Natural Oak Parquete (12%). The smallest- in Hunton Undertak (2%) and Tempered glass plate (1%). The proportions of the influence of other materials are vary from 3% to 9% (Figure 10).

CALCULATIONS FOR CABIN WITH CIRCULAR MATERIALS

The latest calculations for the cabin were made with the maximum amount of recused materials, which had a significant impact on the amount of emissions created, with only 160.46 $kgCO_{2eq}$ from material production, where biogenic carbon storage would be 317.8 $kgCO_{2eq\ bio}$ (Table 15). These figures show how much emissions can be reduced in constructing such cabins if the materials are reused. The most significant embodied emissions per building component are located in the outer roof structures (39%) and in the floor structures (33%), the least - in the superstructure (0%) and in the inner wall structure (1%) (Figure 11). The largest amount of embodied emissions from materials had been detected in Hunton Silencio Parkettunderlag (33%). Other categories are almost equal, where emissions from material vary from 12% to 22% (Figure 12).

EMISSIONS FROM TRANSPORTATION

To calculate emissions from the A4 stage, two calculations were carried out in the One-Click LCA program. This was done due to the complex logistics of the project and prototype, where the construction site's location differs from the building's final location.

For the prototype, the calculation was made as follows. First, the nearest locations for the production of new materials were identified, the distance to the construction site was measured, and the transportation method was found in EPDs for each material. Next, transport distances for second-hand materials were identified; the transport was presented by minivan, which our thesis team rented and used to transport these materials. The sum of these values was used to calculate the first leg of the journey. The same transport method, lorry, and the same distance of 112 km from the construction site to the final destination were used to calculate the second leg of the journey for all materials used (Table 13).

The same method was used to calculate transport emissions for the cabin with proposed brand new materials. However, since this case does not use reused materials, the option of their transportation on a minivan was excluded from the calculations (Table 14).

A similar approach was used to calculate emissions from transportation in a cabin with proposed and maximum reused materials. The only addition to this calculation was the part with re-used materials. Since it is impossible to know for sure where this material will be located, it was proposed to use the same approximate distance of 50 kilometers from the location of the material to the construction site. This distance was chosen to calculate only those materials that are located in and around Bodø. The combined method was chosen as the transportation method (Table 15).

EMISSIONS FROM CONSTRUCTION PROCESS

To calculate emissions from the construction stage of the cabin, practical observations of its construction were used. Based on observations, it can be concluded that the primary resources spent were used for lighting the construction site and for recharging the batteries of building tools.

Based on the article "Energy demand in the Norwegian building stock" average energy consumption per square meter per year was taken. Thus a building similar to the one in which construction work took place consumes 17kWh /sqm/year. Let us look at the initial data for the calculation:

Warehouse energy consumption per square meter per year (E_{wh}) = 17 kWh /sqm/ year =17 kWh /1 sqm/8760 hours

Average emission factor of Norway (EmF) = 0.132 kg CO_{2eq}/kWh

Construction tent area (A) = 588 sqm

Number of light hours used in construction (H) = 90 hours

Thus, the following formula can be formed:

E_{tent}= Ewh/ 8760 hours H* A = 17 kWh /sqm/ year / 8760 hours * 90 hours * 588 sqm = 102 kWh*

To calculate the number of created emissions (Emissions$_1$), the resulting Etent value must be multiplied by the average emission factor of Norway (EmF).

$Emissions_1$ = E_{tent} EmF= 102 kWh * 0.132 kgCO_{2eq}/ kWh = 13.5 kgCO_{2e}*

To calculate emissions from electricity spent on recharging batteries for work equipment, the following formula was developed:

$Emissions_2$ = (V I* $N_{charges}$ * $N_{batteries}$) / 1000 * EmF, where*

Average emission factor of Norway (EmF) = 0.132 kg CO_{2eq}/kWh

Volt of batterie (V) = 18 V

Amp hours of batterie (I) = 5 Ah

Number of total charges for 1 batterie ($N_{charges}$) = 20

Amount of batteries ($N_{batteries}$) = 13

$Emissions_2$ = (18 V 5 Ah* 20 * 13) / 1000 * 0.132 kg CO_{2eq}/kWh = 3.08 kgCO_{2e}*

Thus, the amount of emissions from the cabin's construction is the sum of *$Emissions_1$* and *$Emissions_2$* and is 16,59 kgCO_{2e} for all three variations of the cabin (Tables 13, 14, 15).

TABLE 13. Embodied emissions of cabin prototype

Building Element	Product	Amount	Unit	A1-A3 Product Stage ($kgCO_2e$)	A1-A3 Biogenic carbon storage ($kg\ CO_2e$ bio)	A4 Transportation ($kgCO_2e$)	Reference
2 Building							
22 Superstructure	Pressure impregnated timber, 48 mm * 98 mm	151	m	43,7	566	29,4	NEPD-472-330-NO (2016)
	Pressure impregnated timber, 48 mm * 148 mm	50,3	m	22,1	287	14,94	NEPD-472-330-NO (2016)
23 Outher Walls	Plywood sheets, 1250mm * 1250 mm, thickness 12mm	3,53	m²	1,14	30,9	2,79	NEPD-1579-604 (2018)
	Interior pine pannels, 120mm * 13mm	270	m	25,9	336	16,03	NEPD-2546-1284-NO (2020)
	Hunton Intello Plus, 1500mm * 50000mm, thickness 0,2mm	38,28	m²	20	0	0,78	TG 20557 (2020)
	Hunton Vindett Plus, 1200mm * 2740 mm, thickness 12mm	38,28	m²	22,8	160	11,82	NEPD-1247-400-NO (2017)
	Hunton Nativo Trefiberisolasjon plate, 565mm * 1220mm, thickness 100mm	38,28	m²	57	297	16,17	NEPD-2287-1041-NO (2020)
	Rockwool I-PLATE A, 1200mm * 600 mm, thickness 100mm	2,04	m²	14,9	0	0,76	NEPD-1762-735-EN (2019)
	Pressure impregnated timber, 48 mm * 10 mm	5	m	0,148	1,91	0,09	NEPD-472-330-NO (2016)
	Pressure impregnated timber, 48 mm * 30 mm	105	m	9,29	120	6,26	NEPD-472-330-NO (2016)
	Untreated pine cladding, 145mm * 16mm	470	m	48,6	779	9,84	MD-20004-EN (2020)
	Fliselim plaster board 1000mm * 1250 mm	1,25	m²	11,8	0	7,67	NEPD-2517-1255-EN (2020)
	NorDan small window top hinged, white wooden frame, 1000mm * 400mm	2	pc	0	0	0,36	NEPD-3458-2057 (2020)
	NorDan Villa top swingwith valve, white wooden frame, 1100 mm * 1200 mm	1	pc	0	0	1,25	NEPD-3457-2057 (2022)
	Opus Ytterdør, white, 800mm * 2000mm	2	pc	59	131,2	1,44	One Click LCA
24 Inner Walls	Plywood sheets, 1250mm * 1250 mm, thickness 12mm	2,04	m²	0,659	17,9	1,62	NEPD-1579-604 (2018)
	Interior pine pannels, 120mm * 13mm	7,9	m	0,74	9,6	0,46	NEPD-2546-1284-NO (2020)
	Hunton Intello Plus, 1500mm * 50000mm, thickness 0,2mm	4,08	m²	2,13	0	0,08	TG 20557 (2020)
	Hunton Vindett Plus, 1200mm * 2740 mm, thickness 12mm	2,04	m²	1,22	8,55	0,62	NEPD-1247-400-NO (2017)
	Hunton Nativo Trefiberisolasjon plate, 565mm * 1220mm, thickness 100mm	2,04	m²	3,04	15,8	0,85	NEPD-2287-1041-NO (2020)
	Pressure impregnated timber, 48 mm * 10 mm	5	m	0,148	1,91	0,09	NEPD-472-330-NO (2016)
	Fliselim plaster board 1000mm * 1250 mm	1,25	m²	11,8	0	7,67	NEPD-2517-1255-EN (2020)
25 Floor Structure	Temprered glass plate, 1000mm * 1000mm, thickness 4mm	1	m²	8,02	0	0,15	One Click LCA
	Oak Recycled Parquete	12	m²	0	0	16,3	MD-19009-EN (2020)
	OSB Plate, 2400mm * 1220mm, thickness 12mm	30	m²	12,5	174	3,78	One Click LCA
	Hunton Nativo Trefiberisolasjon plate, 565mm * 1220mm, thickness 100mm	4,1	m²	6,11	31,8	1,72	NEPD-2287-1041-NO (2020)
	Hunton Nativo Trefiberisolasjon plate, 565mm * 1220mm, thickness 150mm	7,9	m²	17,7	92	4,99	NEPD-2287-1041-NO (2020)
	Roof overlay Self-builder 3 °, 1000 mm * 7000 mm, thickness 3 mm	1,3	m²	2,84	0	0,61	NEPD-2597-1318-EN (2021)
	Pressure impregnated timber, 48 mm * 30 mm	19,2	m	1,66	21,5	1,11	NEPD-472-330-NO (2016)

TABLE 13. Embodied emissions of cabin prototype (continued)

Building Element	Product	Amount	Unit	A1-A3 Product Stage ($kgCO_2e$)	A1-A3 Biogenic carbon storage (kg CO_2e bio)	A4 Transportation ($kgCO_2e$)	Reference
2 Building							
26 Outer Roof	Roof overlay Self-builder 3 °, 1000 mm * 7000 mm, thickness 3 mm	16,5	m²	36,1	0	7,84	NEPD-2597-1318-EN (2021)
	OSB Plate, 2400mm * 1220mm, thickness 12mm	45	m²	18,8	261	5,67	One Click LCA
	Pressure impregnated timber, 48 mm * 48 mm	29,4	m	4,12	53,4	2,78	NEPD-472-330-NO (2016)
	Hunton Nativo Trefiberisolasjon plate, 565mm * 1220mm, thickness 150mm	14	m²	31,3	163	8,85	NEPD-2287-1041-NO (2020)
	Hunton Intello Plus, 1500mm * 50000mm, thickness 0,2mm	15	m²	7,83	0	0,307	TG 20557 (2020)
	Interior pine pannels, 120mm * 13mm	132	m	12,6	164	7,92	NEPD-2546-1284-NO (2020)
					Total A1-A3 Biogenic= 3723,5 $kgCO_{2eq}$	Total A4 = 193,02 $kgCO_{2eq}$	Total A5 = 16,59 $kgCO_{2eq}$
Total = 725,2 $kgCO_{2eq}$ = 0,73 tCO_{2eq}				**A1-A3: 515,7 $kgCO_{2eq}$**		**A4-A5: 209,5 $kgCO_{2eq}$**	

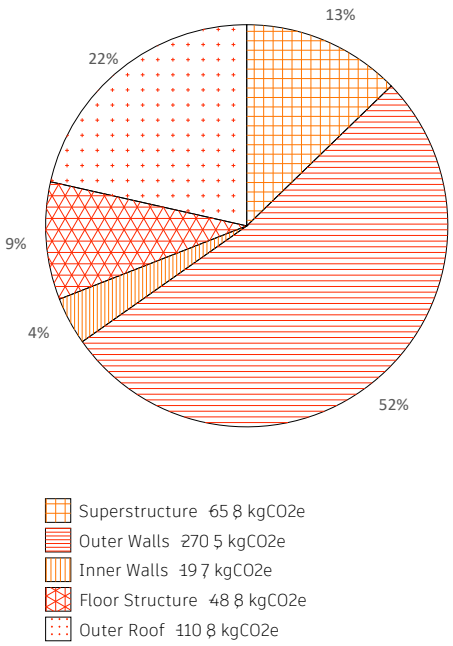


FIGURE 7. Embodied emissions per building component - prototype

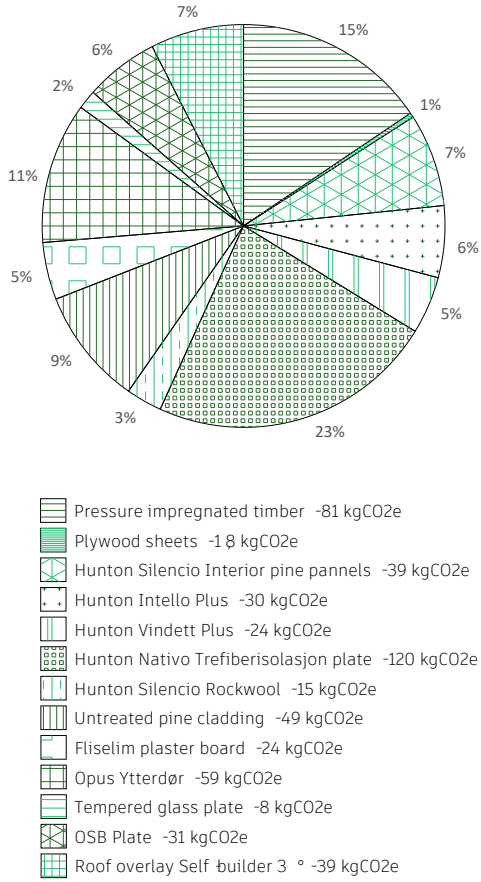


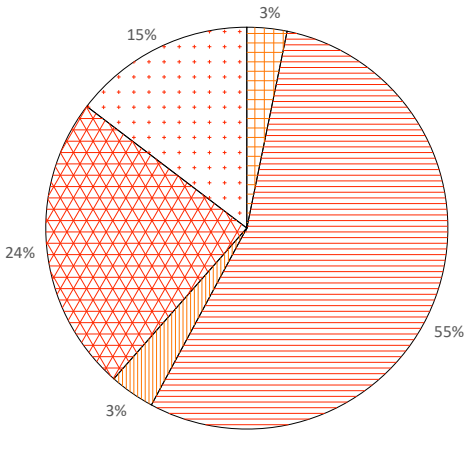
FIGURE 8. Embodied emissions from materials used - prototype

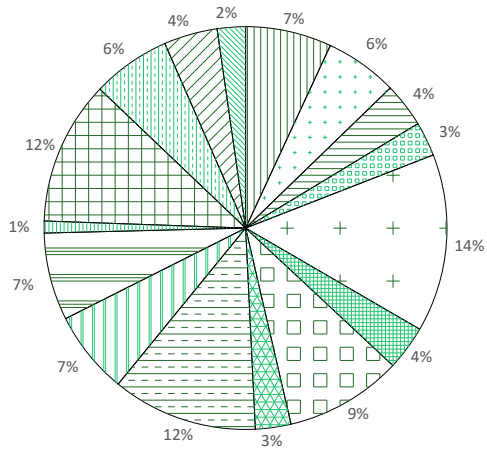
TABLE 14. Embodied emissions of cabin without circular materials

Building Element	Product	Amount	Unit	A1-A3 Product Stage ($kgCO_2e$)	A1-A3 Biogenic carbon storage (kg CO_2e bio)	A4 Transportation ($kgCO_2e$)	Reference
2 Building							
22 Superstructure	Structural timber of pine, 48 mm * 98 mm	151	m	16,8	512	5,87	NEPD-1576-605-NO (2018)
	Structural timber of pine, 48 mm * 148 mm	20,9	m	3,49	107	1,22	NEPD-1576-605-NO (2018)
	Structural timber of pine, 48 mm * 198 mm	29,4	m	6,58	201	2,3	NEPD-1576-605-NO (2018)
23 Outher Walls	Interior pine pannels, 120mm * 13mm	358	m	34,4	446	21,3	NEPD-2546-1284-NO (2020)
	Hunton Intello Plus, 1500mm * 50000mm, thickness 0,2mm	38,28	m^2	20	0	0,79	TG 20557 (2020)
	Hunton Vindett Plus, 1200mm * 2740 mm, thickness 12mm	38,28	m^2	22,8	160	11,8	NEPD-1247-400-NO (2017)
	Hunton Nativo Trefiberisolasjon plate, 565mm * 1220mm, thickness 100mm	38,28	m^2	57	297	16,1	NEPD-2287-1041-NO (2020)
	Rockwool I-PLATE A, 1200mm * 600 mm, thickness 100mm	2,04	m^2	14,9	0	0,77	NEPD-1762-735-EN (2019)
	Structural timber of pine, 48 mm * 10 mm	5	m	0,05	1,73	0,02	NEPD-1576-605-NO (2018)
	Structural timber of pine, 48 mm * 30 mm	105	m	3,56	109	1,25	NEPD-1576-605-NO (2018)
	Untreated pine core cladding, 173mm * 19mm	210	m	79	869	8,16	NEPD-1816-767-NO (2019)
	Fliselim plaster board 1000mm * 1250 mm	1,25	m^2	11,8	0	7,67	NEPD-2517-1255-EN (2020)
	NorDan small window top hinged, white wooden frame, 1000mm * 400mm	2	pc	56,2	12	0,14	NEPD-3458-2057 (2020)
	NorDan Villa top swingwith valve, white wooden frame, 1100 mm * 1200 mm	1	pc	97,6	19,3	2,44	NEPD-3457-2057 (2022)
	Opus Ytterdør, white, 800mm * 2000mm	2	pc	59	131,2	2,88	One Click LCA
24 Inner Walls	Interior pine pannels, 120mm * 13mm	15,8	m	1,48	19,2	0,92	NEPD-2546-1284-NO (2020)
	Hunton Intello Plus, 1500mm * 50000mm, thickness 0,2mm	4,08	m^2	2,13	0	0,08	TG 20557 (2020)
	Rockwool I-PLATE A, 1200mm * 600 mm, thickness 100mm	2,04	m^2	14,9	0	0,77	NEPD-1762-735-EN (2019)
	Structural timber of pine, 48 mm * 10 mm	5	m	0,05	1,73	0,02	NEPD-1576-605-NO (2018)
	Fliselim plaster board 1000mm * 1250 mm	1,25	m^2	11,8	0	7,67	NEPD-2517-1255-EN (2020)
25 Floor Structure	Temprered glass plate, 1000mm * 1000mm, thickness 4mm	1	m^2	8,02	0	0,15	One Click LCA
	Pergo Lofoten Natural Oak Parquete	12	m^2	96,7	262	13,7	MD-19009-EN (2020)
	Hunton Silencio Parkettunderlag, 600mm * 1800mm, thickness 12mm	12	m^2	52,8	61,2	2	NEPD-2791-1490-NO (2021)
	Structural timber of pine, 198 mm * 36 mm	63	m	10,6	324	3,71	NEPD-1576-605-NO (2018)
	Hunton Nativo Trefiberisolasjon plate, 565mm * 1220mm, thickness 100mm	4,1	m^2	6,11	31,8	1,73	NEPD-2287-1041-NO (2020)
	Hunton Nativo Trefiberisolasjon plate, 565mm * 1220mm, thickness 200mm	7,9	m^2	23,5	123	6,66	NEPD-2287-1041-NO (2020)
	Structural timber of pine, 48 mm * 30 mm	39	m	1,32	40,4	0,46	NEPD-1576-605-NO (2018)

TABLE 14. Embodied emissions of cabin without circular materials (continued)

Building Element	Product	Amount	Unit	A1-A3 Product Stage ($kgCO_{2e}$)	A1-A3 Biogenic carbon storage ($kg\ CO_{2e}$ bio)	A4 Transportation ($kgCO_{2e}$)	Reference
2 Building							
26 Outer Roof	Roof overlay Self-builder 3 °, 1000 mm * 7000 mm, thickness 3 mm	16,5	m^2	36,1	0	7,85	NEPD-2597-1318-EN (2021)
	Structural timber of pine, 198 mm * 36 mm	84	m	14,1	432	4,94	NEPD-1576-605-NO (2018)
	Structural timber of pine, 48 mm * 48 mm	29,4	m	1,58	48,3	0,55	NEPD-1576-605-NO (2018)
	Hunton Nativo Trefiberisolasjon plate, 565mm * 1220mm, thickness 150mm	12	m^2	31,3	163	8,85	NEPD-2287-1041-NO (2020)
	Hunton Undertak, 2420mm * 595mm, thickness 18mm	15	m^2	18,8	96,6	3,84	NEPD-1248-401-NO (2017)
	Hunton Intello Plus, 1500mm * 50000mm, thickness 0,2mm	15	m^2	7,83	0	0,31	TG 20557 (2020)
	Interior pine pannels, 120mm * 13mm	132	m	12,6	164	7,92	NEPD-2546-1284-NO (2020)
					Total A1-A3 Biogenic= 4632,46 $kgCO_{2eq}$	Total A4 = 154,84 $kgCO_{2eq}$	Total A5 = 16,59 $kgCO_{2eq}$
Total = 1006,33 $kgCO_{2eq}$ = 1 tCO_{2eq}				**A1-A3: 834,9 $kgCO_{2eq}$**		**A4-A5: 171,43 $kgCO_{2eq}$**	





Superstructure 26,9 $kgCO_2e$
Outer Walls 456,3 $kgCO_2e$
Inner Walls 30,4 $kgCO_2e$
Floor Structure 199,1 $kgCO_2e$
Outer Roof 122,3 $kgCO_2e$

FIGURE 9. Embodied emissions per building component - cabin without circular materials

Structural timber of pine 58 $kgCO_2e$
Interior pine pannels 49 $kgCO_2e$
Hunton Intello Plus -30 $kgCO_2e$
Hunton Vindett Plus -23 $kgCO_2e$
Hunton Nativo Trefiberisolasjon plate -120 $kgCO_2e$
Rockwool -30 $kgCO_2e$
Hunton Silencio Untreated pine core cladding -79 $kgCO_2e$
Fliselim plaster board -24 $kgCO_2e$
NorDan window 1 -98 $kgCO_2e$
NorDan windows 2 -56 $kgCO_2e$
Hunton Silencio Opus Ytterdør -59 $kgCO_2e$
Tempered glass plate -8 $kgCO_2e$
Pergo Lofoten Natural Oak Parquete -97 $kgCO_2e$
Hunton Silencio Parkettunderlag -53 $kgCO_2e$
Roof overlay Self-builder 3 ° -36 $kgCO_2e$
Hunton Undertak -19 $kgCO_2e$

FIGURE 10. Embodied emissions from materials used - cabin without circular materials

TABLE 15. Embodied emissions of cabin with circular materials

Building Element	Product	Amount	Unit	A1-A3 Product Stage ($kgCO_{2e}$)	A1-A3 Biogenic carbon storage ($kg\ CO_{2e}$ bio)	A4 Transportation ($kgCO_{2e}$)	Reference
2 Building							
22 Superstructure	Structural timber of pine, 48 mm * 98 mm	151	m	0	0	5,88	NEPD-1576-605-NO (2018)
	Structural timber of pine, 48 mm * 148 mm	20,9	m	0	0	1,23	NEPD-1576-605-NO (2018)
	Structural timber of pine, 48 mm * 198 mm	29,4	m	0	0	2,31	NEPD-1576-605-NO (2018)
23 Outher Walls	Interior pine pannels, 120mm * 13mm	358	m	0	0	4,59	NEPD-2546-1284-NO (2020)
	Hunton Intello Plus, 1500mm * 50000mm, thickness 0,2mm	38,28	m^2	20	0	0,79	TG 20557 (2020)
	Hunton Vindett Plus, 1200mm * 2740 mm, thickness 12mm	38,28	m^2	22,8	160	11,8	NEPD-1247-400-NO (2017)
	Hunton Nativo Trefiberisolasjon plate, 565mm * 1220mm, thickness 100mm	38,28	m^2	0	0	3,3	NEPD-2287-1041-NO (2020)
	Rockwool I-PLATE A, 1200mm * 600 mm, thickness 100mm	2,04	m^2	0	0	0,22	NEPD-1762-735-EN (2019)
	Structural timber of pine, 48 mm * 10 mm	5	m	0	0	0,02	NEPD-1576-605-NO (2018)
	Structural timber of pine, 48 mm * 30 mm	105	m	0	0	1,25	NEPD-1576-605-NO (2018)
	Untreated pine core cladding, 173mm * 19mm	210	m	0	0	8,18	NEPD-1816-767-NO (2019)
	Fliselim plaster board 1000mm * 1250 mm	1,25	m^2	0	0	0,88	NEPD-2517-1255-EN (2020)
	NorDan small window top hinged, white wooden frame, 1000mm * 400mm	2	pc	0	0	0,48	NEPD-3458-2057 (2020)
	NorDan Villa top swingwith valve, white wooden frame, 1100 mm * 1200 mm	1	pc	0	0	0,84	NEPD-3457-2057 (2022)
	Opus Ytterdør, white, 800mm * 2000mm	2	pc	0	0	1,22	One Click LCA
24 Inner Walls	Interior pine pannels, 120mm * 13mm	15,8	m	0	0	0,21	NEPD-2546-1284-NO (2020)
	Hunton Intello Plus, 1500mm * 50000mm, thickness 0,2mm	4,08	m^2	2,13	0	0,084	TG 20557 (2020)
	Rockwool I-PLATE A, 1200mm * 600 mm, thickness 100mm	2,04	m^2	0	0	0,23	NEPD-1762-735-EN (2019)
	Structural timber of pine, 48 mm * 10 mm	5	m	0	0	0,02	NEPD-1576-605-NO (2018)
	Fliselim plaster board 1000mm * 1250 mm	1,25	m^2	0	0	0,88	NEPD-2517-1255-EN (2020)
25 Floor Structure	Temprered glass plate, 1000mm * 1000mm, thickness 4mm	1	m^2	0	0	0,17	One Click LCA
	Pergo Lofoten Natural Oak Parquete	12	m^2	0	0	2,7	MD-19009-EN (2020)
	Hunton Silencio Parkettunderlag, 600mm * 1800mm, thickness 12mm	12	m^2	52,8	61,2	2	NEPD-2791-1490-NO (2021)
	Structural timber of pine, 198 mm * 36 mm	63	m	0	0	3,72	NEPD-1576-605-NO (2018)
	Hunton Nativo Trefiberisolasjon plate, 565mm * 1220mm, thickness 100mm	4,1	m^2	0	0	0,35	NEPD-2287-1041-NO (2020)
	Hunton Nativo Trefiberisolasjon plate, 565mm * 1220mm, thickness 200mm	7,9	m^2	0	0	1,36	NEPD-2287-1041-NO (2020)
	Structural timber of pine, 48 mm * 30 mm	39	m	0	0	0,46	NEPD-1576-605-NO (2018)

TABLE 15. Embodied emissions of cabin with circular materials (continued)

Building Element	Product	Amount	Unit	A1-A3 Product Stage ($kgCO_{2e}$)	A1-A3 Biogenic carbon storage (kg CO_{2e} bio)	A4 Transportation ($kgCO_{2e}$)	Reference
2 Building							
26 Outer Roof	Roof overlay Self-builder 3 °, 1000 mm * 7000 mm, thickness 3 mm	16,5	m^2	36,1	0	7,85	NEPD-2597-1318-EN (2021)
	Structural timber of pine, 198 mm * 36 mm	84	m	0	0	4,95	NEPD-1576-605-NO (2018)
	Structural timber of pine, 48 mm * 48 mm	29,4	m	0	0	0,55	NEPD-1576-605-NO (2018)
	Hunton Nativo Trefiberisolasjon plate, 565mm * 1220mm, thickness 150mm	12	m^2	0	0	1,81	NEPD-2287-1041-NO (2020)
	Hunton Undertak, 2420mm * 595mm, thickness 18mm	15	m^2	18,8	96,6	3,84	NEPD-1248-401-NO (2017)
	Hunton Intello Plus, 1500mm * 50000mm, thickness 0,2mm	15	m^2	7,83	0	0,31	TG 20557 (2020)
	Interior pine pannels, 120mm * 13mm	132	m	0	0	1,8	NEPD-2546-1284-NO (2020)
					Total A1-A3 Biogenic= 317,8 $kgCO_{2eq}$	Total A4 = 76,28 $kgCO_{2eq}$	Total A5 = 16,59 $kgCO_{2eq}$
Total = 253,34 $kgCO_{2eq}$ = 0,25 tCO_{2eq}				**A1-A3: 160,46 $kgCO_{2eq}$**		**A4-A5: 92,87 $kgCO_{2eq}$**	

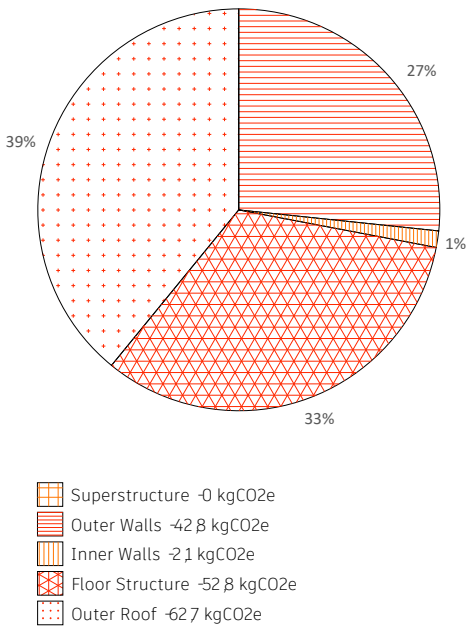


FIGURE 11. Embodied emissions per building component - cabin with circular materials

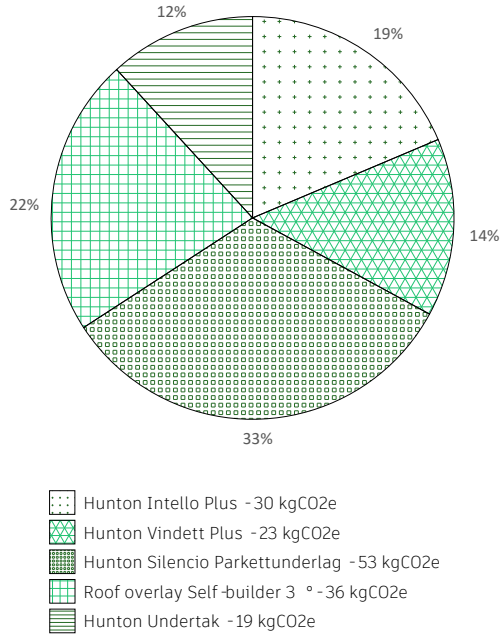


FIGURE 12. Embodied emissions from materials used - cabin with circular materials

RESULTS

After comparing the LCA of three sets of materials of the same cabin design, the following conclusions can be drawn:

1. Total emissions from cradle to the site (A1-A5) over a lifetime of 60 years for the three cabin variations (prototype; cabin with an improved list of materials; cabin with an improved set of materials, where the maximum of materials would be reused) are 725.2 $kgCO_{2eq}$, 1006.33 $kgCO_{2eq}$, and 253.34 $kgCO_{2eq}$ respectively (Figure 13). The difference between the three indicators is very significant, and it is related to the use of reused materials in the project. Reused materials and elements (parquet flooring and windows) were introduced into the prototype, which made it possible to significantly reduce emissions compared to a second cabin with an improved set of materials, where all materials are entirely new (Figures 8, 10). At the same time, the difference between the second and third cabin options is even greater, which again demonstrates how significant the impact of reused materials is on the sustainability of the project. The conclusion is that the introduction of circular materials in the design of cabins has a very high environmental potential and will help to reduce emissions significantly. A summary of the embodied emissions for all three cabins variations is presented in Table 16.

2. Biogenic carbon storage for all three cabin options prevails over emissions generated from stages A1-A5. This result was caused by the "wood" nature of most materials chosen for the project (Figure 13).

3. Hunton Nativo Trefiberisolasjon thermal insulation has the most significant contribution in terms of emissions in the prototype and second cabin. In the third cabin, thermal insulation is not included in the calculation, as it can be reused. This type of insulation leaves an open discussion about its possible replacement with more sustainable options after testing its performance in the prototype (resistance to destruction from pests and weather conditions, thermal qualities, resistance to transportation).

A1-A3	Prototype	Proposed cabin without re-used materials	Proposed cabin with re-used materials
Total emissions over 60 years (kgCO2eq)	515	835	160
Annualized specific emissions ($kgCO2eq/m^2/y$)	0,85	1,39	0,26
A4			
Total emissions over 60 years (kgCO2eq)	193	155	76
Annualized specific emissions ($kgCO2eq/m^2/y$)	0,32	0,26	0,13
A5			
Total emissions over 60 years (kgCO2eq)	17	17	17
Annualized specific emissions ($kgCO2eq/m^2/y$)	0,03	0,03	0,03
Total			
Total emissions over 60 years (kgCO2eq)	725	1007	253
Annualized specific emissions ($kgCO2eq/m^2/y$)	1,21	1,68	0,42

TABLE 16. Total embodied emissions

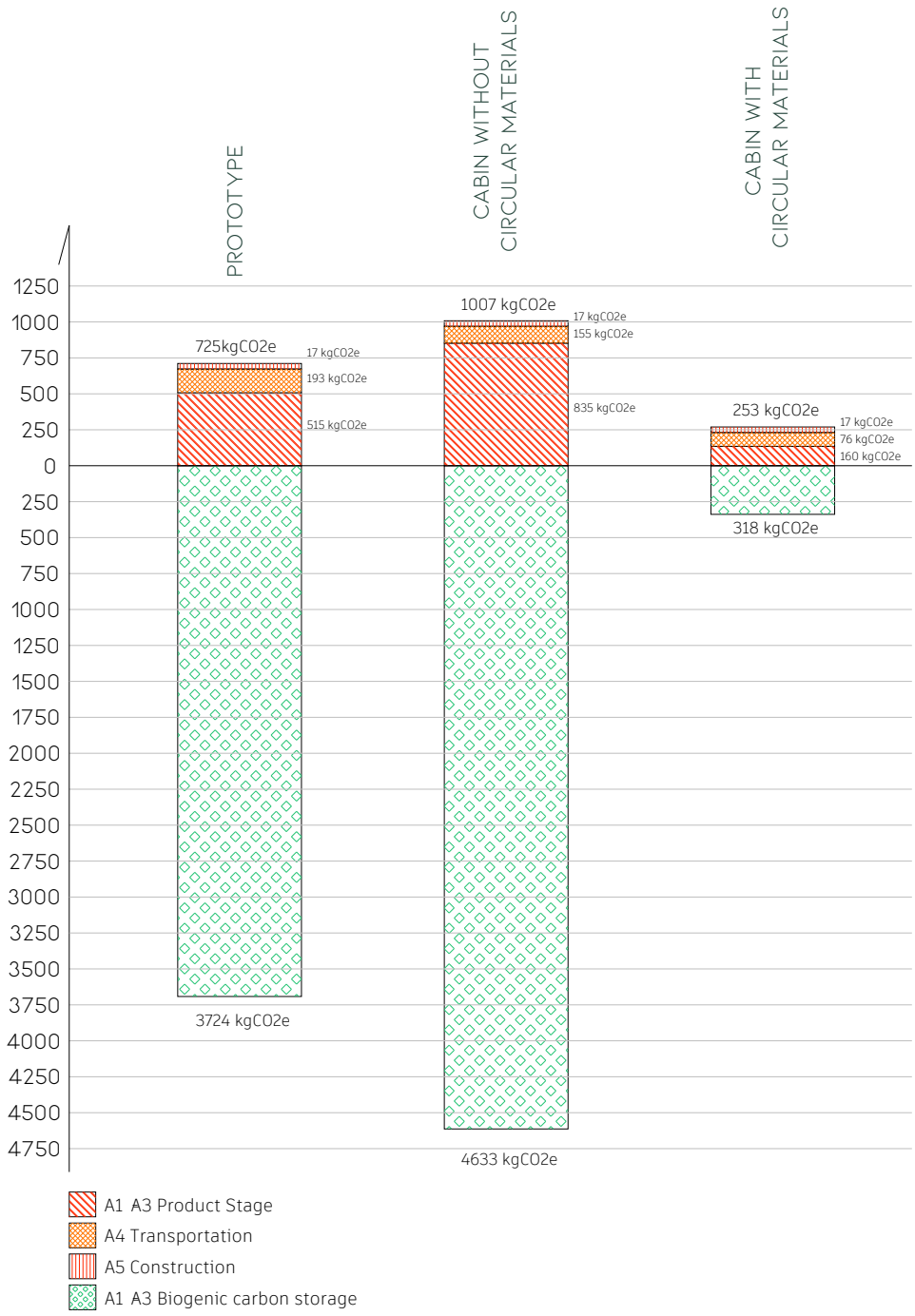


FIGURE 13. Comparison of embodied emissions of cabin variations

V. CONCLUSION

Considering the incredible popularity of private cabins in Norway, their ubiquity, and their impact on the environment, the idea of creating sustainable cabins with a small footprint is very promising. By order of DNT, our thesis group proposed and built a variant of such a cabin, which was demonstrated at the Landskonferanse Friluftsliv exhibition and will be transported to the Nordlandsruta trail in July. During the research, design, and construction stages, a massive amount of work was done, and various group and individual decisions were made. This study is part of a larger study on the performance of the designed cabin; it describes decisions made regarding the chosen materials of construction and their impact on the weight of the structure and on the environment in the context of LCA.

The experience gained from the possibility of building our design has demonstrated how many unexplored building aspects exist. Some materials selected during the study were not available for purchase at the construction time, which affected the design decisions. There were also some mistakes in the initial choice of materials, some of which were corrected in time, while others had to be learned to integrate. However, this experience has had a significant impact on our understanding of building technologies, actual applications, and the performance of materials. We realized that pre-planned solutions cannot always be implemented for reasons beyond our control and that backup solutions should exist. However, inconsistencies and errors were taken into account for further investigation.

The boundaries of the structure's weight were set at the very beginning of the design. The proposed design, both the prototype and the cabins with an improved set of materials, do not exceed the established limit of 3.6 tons. It confirms that the cabin can subsequently be transported anywhere, regardless of the place of its construction.

The LCA study for three cabin options demonstrated not only the environmental impact of the built prototype but also of its other variants. Analysis of the cabin option with the maximum amount of reused materials demonstrated the importance of their implementation in subsequent projects by significantly reducing the amount of emissions from stages A1-A4.

Further work on the cabin includes, but not limited:

- Testing the prototype on the site will demonstrate the qualities and shortcomings of the selected technologies and materials;
- Analyzing other possible materials, calculating their environmental impact;
- Collecting feedback from future users and DNT will help draw conclusions about the work done and help implement the necessary changes.

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APPENDICES

APPENDIX A: MATERIAL ORDER LIST 19.04.22

TILBUD

Kunde: 318337
SALTEN REGIONRÅD
V/SALTEN FRILUFTSRÅD
SJØGATA 27
8006 BODØ

Foretaksregisteret
Org.nr.: NO 993075485 MVA
Bankgiro: 47504224577

XL-BYGG KÅRE ABELSEN AS
TØMRERVEIEN 2

8004 Bodø

Tlf.: 75 50 42 50
Epost: firmapost@abelsen.no

Leveringsadresse:
SALTEN REGIONRÅD
V/SALTEN FRILUFTSRÅD
SJØGATA 27
8006 BODØ

Tilbud: 940836/00

Leveringsdato: 19.04.22
Leveringsmåte: Hentes

Vår ref: Endre Nilsen
Kundens ref: Bjørn Godal
Mob: 48256683

Bet. betingelser: 30 dgr nto
Dato: 19.04.22
Kl.: 13:52:26
Gyldig til: 19.05.22

Varenr.	*Varetekst*	*Antall*	*Enhet*	*LT*	*Mva %*	*Pris*	*Rab %*	*Netto sum*
48062242	FURU 19X173 REK KLED MALM 90%	250,00	LM		25,00	121,50	30,00	21 262,50
	MALM REK 19X173							
26924829	ANBREKKSTILLEGG	1,00	STK		25,00	580,00		580,00
00000112	FRAKT ALVDAL	1,00	STK		25,00	1 460,00		1 460,00
	LEVERING TIDLIGST UKE 19							
53607241	FURU 30X048 LEKT BUNTET LP NTR AB	84,00	LM		25,00	18,32	30,00	1 077,22
57964461	FURU 48X098 C24 LP NTR AB IMP 4,80+	116,00	LM		25,00	59,92	30,00	4 865,50
	LOGISTIKNUMMER 4,8+							
53547862	FURU 48X148 JUST C24 IMP AB LP	95,000	LM		25,00	79,20	30,00	5 266,80
53547877	FURU 48X198 JUST C24 IMP AB LP	29,000	LM		25,00	63,92	TILB	1 853,68
55412117	NATIVO TREFIBISOLASJON 150X565X1200	10,00	PAK		25,00	356,75	35,00	2 318,87
	TREFIBERISOLASJON PLATE							
24647935	VINDTETT PLUS TREFIBPL 15X1200X2740	13,00	PLA		25,00	437,27	25,00	4 263,38
	HUNTON VINDSPERRE PLUS TREFIB PLATE							
55406733	NATIVO TREF ISOLASJON 100X565X1220	24,00	PAK		25,00	317,16	35,00	4 947,70
	TREFIBERISOLASJON PLATE							
48662494	DAMPBREMS INTELLO PLUS 1,5 M	2,00	RUL		25,00	5 113,46	25,00	7 670,19
	HUNTON INTELLO PLUS A 50 M							
22512743	TREFIBERPLATE UNDERTAK 18X595X2420	12,00	PLA		25,00	237,33	35,00	1 851,17
	HUNTON UNDERTAK							
22064166	SILENCIO PARKETTUNDERL 12X600X1800	8,00	PLA		25,00	115,70	35,00	601,64
	TREFIBERPLATE 12 600 1800							
26924829	ANBREKKSTILLEGG	3,00	STK		25,00	550,00		1 650,00
00000112	FRAKT HUNTON	1,00	STK		25,00	3 900,00		3 900,00
	LEVERINGSTID CA 3 UKER							
20003142	KRYSSF FURU B/X 6X2440X1220	6,00	PLA		25,00	1 308,82	45,00	4 319,11
	KRYSSFINER FURU							
22150387	KRYSSF FURU BB/X 9X2440X1220	11,00	PLA		25,00	1 451,86	45,00	8 783,75
	KRYSSFINER FURU							
52075304	FURU 13X120 SKYGGE SKRÅ NATUR	420,00	LM		25,00	45,49	30,00	13 374,06
26924928	PLUKKTILLEGG	1,00	STK		25,00	490,00		490,00
00000112	FRAKT MOELVEN	1,00	STK		25,00	3 300,00		3 300,00
	LEVERINGSTID CA 2 UKER							

TILBUD

Kunde: 318337
SALTEN REGIONRÅD
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8006 BODØ

Tilbud: 940836/00

Leveringsdato:	Vår ref:	Bet. betingelser:	
19.04.22	Endre Nilsen	30 dgr nto	
	Kundens ref:	Dato:	19.04.22
Leveringsmåte:	Bjørn Godal	Kl.:	13:52:26
Hentes	Mob: 48256683	Gyldig til:	19.05.22

Varenr.	*Varetekst*	*Antall*	*Enhet*	*LT*	*Mva %*	*Pris*	*Rab %*	*Netto sum*
53614680	FURU 28X120 ROYAL BRUN TERRASSE UNO RB.10	70,00	LM		25,00	51,92	TILB	3 634,40
48260077	PARKETT 15 EIK COSENZA 242 1 STAV MIKROFAS MATT	3,00	PAK		25,00	1 825,66	5,00	5 203,13
11498730	FRISKLUFTSVENTIL 80T	3,00	STK		25,00	263,20	25,00	592,20
23375975	KLAFFVENTIL UBEHANDLET FURU 150X150	1,00	STK		25,00	279,20	40,00	167,52
45489106	VINDU TH 1.2 SPS UTADSL 985X385	2,00	STK		25,00	5 668,89	50,00	5 668,89
45901293	VINDU NORGESVINDUET 485X485 TOPPHENGSLET	1,00	STK		25,00	5 872,22	50,00	2 936,11
40726234	VINDU NORGESVINDUET 1185X1085 TOPPSVING	1,00	STK		25,00	11 072,22	50,00	5 536,11
26924837	EMBALLASJEOMKOSTNINGER	1,00	STK		25,00	199,00		199,00
26925164	EUROPALL HEL STD	1,00	STK		25,00	136,00		136,00
00010268	MILJØAVGIFT GLASS KAN SENDES FRA LEVERANDØR19.MAI PDD.	4,00	STK		25,00	9,00		36,00
26477349	KARM ID SIDER M20 HV BYGG1	2,00	PAR		25,00	383,20	TILB	766,40
26484808	KARM ID TOPP M7 HV BYGG1 KARMTOPP M7 HVIT	2,00	STK		25,00	127,20	TILB	254,40
55994733	OVN JØTUL F 602 ECO SORT LAKK LEVERING CA JUNI/JULI 2022	1,00	STK		25,00	12 232,00		12 232,00
56023312	SKJERMPLATE SIDE JØTUL F 602 ECO BESTILLINGSVARE	1,00	STK		25,00	948,00	25,00	711,00
53299884	LÅSKASSE 112 INNERDØR	2,00	BK		25,00	127,20	30,00	178,08
51013298	INNERDØRHÅNDTAK 2012 MKR PP	2,00	POS		25,00	151,20	30,00	211,68
	Netto sum eks. mva.							132 298,49
	+ mva.							33 074,62
	Brutto sum inkl. mva.							165 373,11

Tilbudet gjelder kun varer beskrevet i tilbudet. Det tas forbehold om prisstigning fra produsent/leverandør. Tilbudet er basert på levering i hele lass. Det er ingen retur på bestillingsvarer med mindre dette er avtalt og skriftlig godkjent på forhånd. Kunden står selv ansvarlig for masseberegning og varevalg. Fraktomkostninger og betalingsbetingelser i hennhold til avtale. Retur av lagervarer må avtales på forhånd og skriftlig godkjennes av saksbehandler før tilbakesending. Mengde kan bli justert ihht. hele plater/pakker ved levering. Varer selges ihht. XL-BYGG KÅRE ABELSEN AS sine til enhver tid gjeldende salgs og leveringsbetingelser som er tilgjengelig på xl-bygg.no

APPENDIX B: MATERIAL ORDER LIST 26.04.2022

ORDREBEKREFTELSE

Kunde: 318337
SALTEN REGIONRÅD
V/SALTEN FRILUFTSRÅD
SJØGATA 27
8006 BODØ

Foretaksregisteret
Org.nr.: NO 993075485 MVA
Bankgiro: 47504224577

XL-BYGG KÅRE ABELSEN AS
TØMRERVEIEN 2

8004 Bodø

Tlf.: 75 50 42 50
Epost: firmapost@abelsen.no

Leveringsadresse:
LEVERES BÅDIN BRYGGERI
SE KART
KONTAKT SAMI, TLF 90519005

Ordre: 839309/00

Leveringsdato: 02.05.22
Leveringsmåte: Kjøres
Rekvisisjon:

Vår ref: Endre Nilsen
Tlf.:
Epost:
Kundens ref: Bjørn Godal
Mob: 48256683

Bet. betingelser: 30 dgr nto

Dato: 26.04.22
Kl.: 15:28:59

Varenr.	*Varetekst*	*Best.*	*Antall*	*Enhet*	*LT*	*Mva %*	*Pris*	*Rabatt %*	*Sum beløp*
57964037	GRAN 19X148 R-K LP 4,80+ LOGISTIKNUMMER 4,8+		250,00	LM		25,00	44,72	30,00	7 826,00
53607241	Bekreftet levering 02.05.22 FURU 30X048 LEKT BUNTET LP NTR AB		84,00	LM		25,00	18,32	30,00	1 077,22
57964461	Bekreftet levering 02.05.22 FURU 48X098 C24 LP NTR AB IMP 4,80+ LOGISTIKNUMMER 4,8+		116,00	LM		25,00	59,92	30,00	4 865,50
53547862	Bekreftet levering 02.05.22 FURU 48X148 JUST C24 IMP AB LP		124,00 0	LM		25,00	79,20	30,00	6 874,56
46414056	Bekreftet levering 02.05.22 FURU 48X048 LEKT BUNTET LP NTR AB		29,00	LM		25,00	28,72	30,00	583,02
20003142	Bekreftet levering 02.05.22 KRYSSF FURU B/X 6X2440X1220 KRYSSFINER FURU		6,00	PLA		25,00	1 308,82	45,00	4 319,11
22150395	Bekreftet levering 02.05.22 KRYSSF FURU BB/X 12X2440X1220 KRYSSFINER FURU		11,00	PLA		25,00	1 880,98	35,00	13 449,01
52075573	Bekreftet levering 02.05.22 FURU 13X120 SPREKK NATUR SPREKKPANEL NATUR UBEH		420,00	LM		25,00	28,95		12 159,00
53614680	Bekreftet levering 02.05.22 FURU 28X120 ROYAL BRUN TERRASSE UNO RB.10		70,00	LM		25,00	51,92		3 634,40
11498730	Bekreftet levering 02.05.22 FRISKLUFTSVENTIL 80T		3,00	STK		25,00	263,20	25,00	592,20
23375975	Bekreftet levering 02.05.22 KLAFFVENTIL UBEHANDLET FURU 150X150		1,00	STK		25,00	279,20	40,00	167,52
26182154	Bekreftet levering 02.05.22 KRYSSF RED TEMPERATE 12X2440X1220SK		6,00	PLA		25,00	1 213,46	35,00	4 732,49

Kid-nummer:	**Betal til konto:**	**Forskudd/betalingskrav:**
null	**null**	**null**

XL-BYGG KÅRE ABELSEN AS har salgspant i solgte varer inntil kjøpesum med tillegg av rente og omkostninger i sin helhet er betalt. Etter forfall beregnes renter i henhold til lov om forsinket betaling.
Reklamasjon må skje skriftlig til firmapost@abelsen.no ved varens mottagelse. Varer selges ihht. XL-BYGG KÅRE ABELSEN AS til enhver tid gjeldende salgs og leveringsbetingelser som er tilgjengelig påxl-bygg.no

ORDREBEKREFTELSE

Foretaksregisteret
Org.nr.: NO 993075485 MVA
Bankgiro: 47504224577

XL-BYGG KÅRE ABELSEN AS
TØMRERVEIEN 2

8004 Bodø

Tlf.: 75 50 42 50
Epost: firmapost@abelsen.no

Kunde: 318337
SALTEN REGIONRÅD
V/SALTEN FRILUFTSRÅD
SJØGATA 27
8006 BODØ

Ordre: 839309/00

Leveringsadresse:
LEVERES BÅDIN BRYGGERI
SE KART
KONTAKT SAMI, TLF 90519005

Leveringsdato: 02.05.22
Leveringsmåte: Kjøres
Rekvisisjon:

Vår ref: Endre Nilsen
Tlf.:
Epost:
Kundens ref: Bjørn Godal
Mob: 48256683

Bet. betingelser: 30 dgr nto
Dato: 26.04.22
Kl.: 15:28:59

Varenr.	*Varetekst*	*Best.*	*Antall*	*Enhet*	*LT*	*Mva %*	*Pris*	*Rabatt %*	*Sum beløp*
	KRYSSFINER POPPEL								
	Bekreftet levering 02.05.22								
50978597	VINDSPERRE SOFT XTRA 1,30X25M ISOLA		1,00	RUL		25,00	2 199,20	25,00	1 649,40
	Bekreftet levering 02.05.22								
43656597	OSB3 ZERO 12X2400X1220 TG2		6,00	PLA		25,00	771,18	35,00	3 007,60
	STERLING								
	Bekreftet levering 02.05.22								
25553579	HARDVOKSOLJE 3062 0,75L MATT		3,00	STK		25,00	527,20	25,00	1 186,20
	1L DEKKER CA 24M2 1 STRØK								
	Bekreftet levering 02.05.22								
56342046	OVERLAG SELVBYGGER 3GR 1X7M SORT NY		3,00	RUL		25,00	2 279,20	35,00	4 444,44
	MATAKI								
	Bekreftet levering 02.05.22								
26924837	EMBALLASJEOMKOSTNINGER		1,00	STK		25,00	20,00		20,00
	Bekreftet levering 02.05.22								
00000501	TRANSPORT SONE 1 SENTRUM		1,00	STK		25,00	256,00		256,00
	INNENFOR BOMRING								
	Bekreftet levering 02.05.22								
	Netto sum eks. mva.								70 843,67
	+ mva.								17710,91
	Brutto sum inkl. mva.								88 554,58

Kid-nummer:	Betal til konto:	Forskudd/betalingskrav:
null	null	null

APPENDIX C: MATERIAL ORDER LIST 06.05.2022

PAKKSEDDEL

Kunde: 318337
SALTEN REGIONRÅD
V/SALTEN FRILUFTSRÅD
SJØGATA 27
8006 BODØ

Foretaksregisteret
Org.nr.: NO 993075485 MVA
Bankgiro: 47504224577

XL-BYGG KÅRE ABELSEN AS
TØMRERVEIEN 2

8004 Bodø

Tlf.: 75 50 42 50
Epost: firmapost@abelsen.no

Leveringsadresse:
SALTEN REGIONRÅD
LEVERES BÅDIN BRYGGERI
FØRSTE TUR
RING KUNDE 94986242

Ordre: 839956/01

Mottakerinfo:
.
Mob: 48256683

Leveringsdato: 09.05.22

Leveringsmåte: Kjøres

Vår ref: Robin Arntsberg
Kundens ref: .
Mob: 48256683
Rekvisisjon:

Bet. betingelser: 30 dgr nto
Dato: 06.05.22
Kl.: 14:26:21
Lev. dato: 09.05.22

Varenr.	*Varetekst*	*Best.*	*Antall*	*Enhet*	*LT*	*Pris*	*Lager*	*Nobb-nr.*
57964037	GRAN 19X148 R-K LP 4,80+		153,00	LM	0	44,72	10	57964037
	LOGISTIKNUMMER 4,8+							
00000501	TRANSPORT SONE 1 SENTRUM		1,00	STK	0	256,00	10	
	INNENFOR BOMRING							
	TRELAST: 1							

Dato: _____ / _____ / _____ Sign:

APPENDIX D: MATERIAL ORDER LIST 09.05.2022

PAKKSEDDEL

Kunde: 318337
SALTEN REGIONRÅD
V/SALTEN FRILUFTSRÅD
SJØGATA 27
8006 BODØ

Foretaksregisteret
Org.nr.: NO 993075485 MVA
Bankgiro: 47504224577

XL-BYGG KÅRE ABELSEN AS
TØMRERVEIEN 2

8004 Bodø

Tlf.: 75 50 42 50
Epost: firmapost@abelsen.no

Leveringsadresse:
DIVERSE PROSJEKT
PB 915
PRINSENSGT 113A

Ordre: 840097/00

Mottakerinfo:
JULIE
Mob: 48256683

Leveringsdato: 09.05.22

Leveringsmåte: FRA KASSE/RADIOTERMI

Vår ref: TONY T EGERDAHL
Kundens ref: JULIE
Mob: 48256683
Rekvisisjon:

Bet. betingelser: 30 dgr nto
Dato: 09.05.22
Kl.: 14:25:16
Lev. dato: 09.05.22

Varenr.	*Varetekst*	*Best.*	*Antall*	*Enhet*	*LT*	*Pris*	*Lager*	*Nobb-nr.*
57130742	FUGESKUM P905 ALL SEASON FLEX COMBI BYGGSKUM BEIGE 750ML		1,00	STK	0	231,20	10	57130742

Dato: _____ / _____ / _____ Sign:

APPENDIX E: MATERIAL ORDER LIST 09.05.2022

PAKKSEDDEL

Kunde: 318337
SALTEN REGIONRÅD
V/SALTEN FRILUFTSRÅD
SJØGATA 27
8006 BODØ

Foretaksregisteret
Org.nr.: NO 993075485 MVA
Bankgiro: 47504224577

XL-BYGG KÅRE ABELSEN AS
TØMRERVEIEN 2

8004 Bodø

Tlf.: 75 50 42 50
Epost: firmapost@abelsen.no

Leveringsadresse:
SALTEN REGIONRÅD
V/SALTEN FRILUFTSRÅD
SJØGATA 27
8006 BODØ

Ordre: 840091/00

Mottakerinfo:
PROTOTYPE HYTTEPROS.
Mob: 48256683

Leveringsdato:
09.05.22

Leveringsmåte:
FRA KASSE/RADIOTERMI

Vår ref:
TONY T EGERDAHL
Kundens ref:
PROTOTYPE HYTTEPROS.
Mob: 48256683
Rekvisisjon:
JULIE

Bet. betingelser:
30 dgr nto
Dato: 09.05.22
Kl.: 14:25:49
Lev. dato: 09.05.22

Varenr.	*Varetekst*	*Best.*	*Antall*	*Enhet*	*LT*	*Pris*	*Lager*	*Nobb-nr.*
11498730	FRISKLUFTSVENTIL 80T		1,00	STK	0	263,20	10	11498730
57128884	SKRUE MED SKIVE 5,2X35MM MATAKI NY TIL SUPER SAFE EXTRA 30 STK		3,000	PAK	0	295,20	10	57128884
55979662	TRESKRUE ESSDRIVE SH 5X90 A4 -100 SENKHODE A4 SYREFAST STÅL		1,00	PAK	0	407,20	10	55979662
47427236	MATAKI ASFALT FUGEMASSE 0,3LTR		3,00	TUB	0	207,20	10	47427236
56036184	UNIVERSALKNIV LUK-90		1,00	STK	0	143,20	10	56036184
43656597	OSB3 ZERO 12X2400X1220 TG2		2,00	PLA	0	888,38	10	43656597

Dato: _____ / _____ / _____ Sign:

APPENDIX F: MATERIAL ORDER LIST 10.05.2022

PAKKSEDDEL

KÅRE ABELSEN

Foretaksregisteret
Org.nr.: NO 993075485 MVA
Bankgiro: 47504224577

XL-BYGG KÅRE ABELSEN AS
TØMRERVEIEN 2

8004 Bodø

Tlf.: 75 50 42 50
Epost: firmapost@abelsen.no

Kunde: 318337
SALTEN REGIONRÅD
V/SALTEN FRILUFTSRÅD
SJØGATA 27
8006 BODØ

Leveringsadresse:
SALTEN REGIONRÅD
V/SALTEN FRILUFTSRÅD
SJØGATA 27
8006 BODØ

Ordre: 840145/00

Mottakerinfo:
JULIE
Mob: 48256683

Leveringsdato: 10.05.22

Leveringsmåte: Fra kasse/radiotermi

Vår ref: TONY T EGERDAHL
Kundens ref: JULIE
Mob: 48256683
Rekvisisjon: PROTOTYPE HYTTE

Bet. betingelser: 30 dgr nto
Dato: 10.05.22
Kl.: 14:24:47
Lev. dato: 10.05.22

Varenr.	*Varetekst*	*Best.*	*Antall*	*Enhet*	*LT*	*Pris*	*Lager*	*Nobb-nr.*
57137973	SLIPERULL P180 115MM X 2,5M 3M SANDING ROLL 115X2,5- P180		1,00	PAK	0	79,92	10	57137973
48028986	SLØYFEBÅND 50MMX15M ISOLA		1,00	RUL	0	615,20	10	48028986
25614637	FARMERSKRUE 4,8X35 SVART A-30 BORSPISS RAL 9011		1,00	PAK	0	191,20	10	25614637
54601025	HULLSAG HSS-BIM POWERCHANGE 86MM		1,00	STK	0	319,20	10	54601025
54601241	HULLSAGADAPTER PCP 8,7MM HSSG 7,15X 85MM		1,00	STK	0	343,20	10	54601241
22763510	TRESPIRALBOR SW10 12X160X235MM		1,00	STK	0	143,20	10	22763510
53575404	FUGEPISTOL MAXI SEALANT GUN 0,3L ROBUST AV METALL		1,00	STK	0	535,20	10	53575404
28458792	HÅNDTAK FOR BAUFILBLAD 704		1,00	STK	0	119,20	10	28458792
43022344	TAPE DAMPSPERRE FLEX 60 ISOLA 60MMX25M		1,00	RUL	0	591,20	10	43022344
57964037	GRAN 19X148 R-K LP 4,80+ LOGISTIKNUMMER 4,8+		51,00	LM	0	44,72	10	57964037

Dato: _____ / _____ / _____ Sign:

APPENDIX G: MATERIAL ORDER LIST 12.05.2022

PAKKSEDDEL

Kunde: 318337
SALTEN REGIONRÅD
V/SALTEN FRILUFTSRÅD
SJØGATA 27
8006 BODØ

Foretaksregisteret
Org.nr.: NO 993075485 MVA
Bankgiro: 47504224577

XL-BYGG KÅRE ABELSEN AS
TØMRERVEIEN 2

8004 Bodø

Tlf.: 75 50 42 50
Epost: firmapost@abelsen.no

Leveringsadresse:
SALTEN REGIONRÅD
V/SALTEN FRILUFTSRÅD
SJØGATA 27
8006 BODØ

Ordre: 840311/00

Mottakerinfo:
JULIE
Mob: 48256683

Leveringsdato: 12.05.22

Leveringsmåte: FRA KASSE/RADIOTERMI

Vår ref: ENDRE NILSEN
Kundens ref: JULIE
Mob: 48256683
Rekvisisjon: SALTEN FRILUFTSRÅD

Bet. betingelser: 30 dgr nto
Dato: 12.05.22
Kl.: 14:24:26
Lev. dato: 12.05.22

Varenr.	*Varetekst*	*Best.*	*Antall*	*Enhet*	*LT*	*Pris*	*Lager*	*Nobb-nr.*
52075573	FURU 13X120 SPREKK NATUR		70,07	LM	0	28,95	10	52075573
56433894	OVERLAG SELVBYGGER 6GR 1X7M SORT NY		1,000	RUL	0	1 719,20	10	56433894

Dato: _____/_____/_____ Sign:

APPENDIX H: MATERIAL ORDER LIST 12.05.2022

PAKKSEDDEL

KÅRE ABELSEN

Foretaksregisteret
Org.nr.: NO 993075485 MVA
Bankgiro: 47504224577

Kunde: 318337
SALTEN REGIONRÅD
V/SALTEN FRILUFTSRÅD
SJØGATA 27
8006 BODØ

XL-BYGG KÅRE ABELSEN AS
TØMRERVEIEN 2

8004 Bodø

Tlf.: 75 50 42 50
Epost: firmapost@abelsen.no

Leveringsadresse:
SALTEN REGIONRÅD
V/SALTEN FRILUFTSRÅD
SJØGATA 27
8006 BODØ

Ordre: 840340/00

Side 1 av 1

Mottakerinfo:

Mob: 48256683

Leveringsdato:
12.05.22

Leveringsmåte:
FRA KASSE/RADIOTERMI

Vår ref:
TONY T EGERDAHL
Kundens ref:

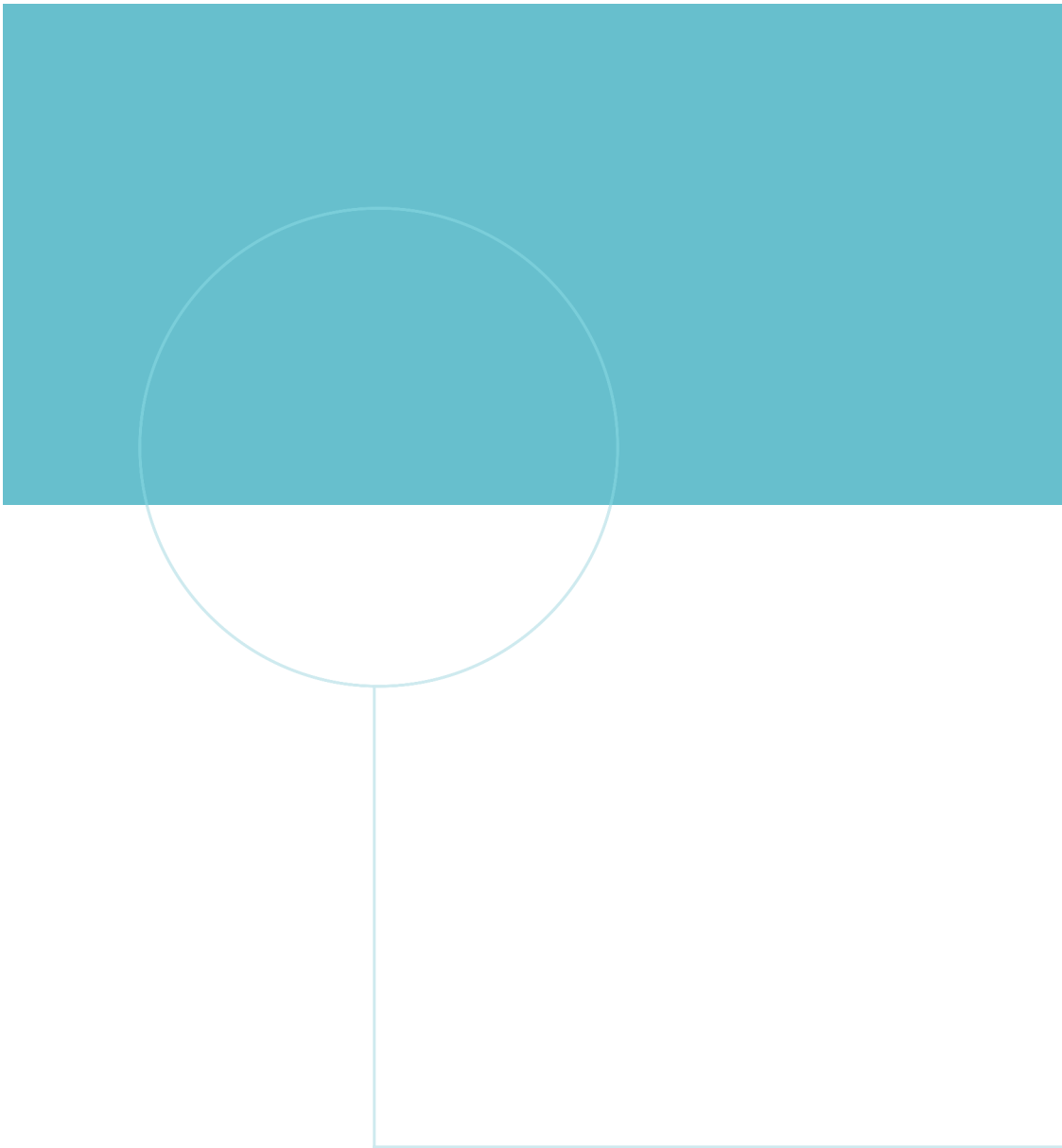
Mob: 48256683
Rekvisisjon:
HYTTE PROSJEKT

Bet. betingelser:
30 dgr nto
Dato: 12.05.22
Kl.: 14:23:23
Lev. dato: 12.05.22

Varenr.	*Varetekst*	*Best.*	*Antall*	*Enhet*	*LT*	*Pris*	*Lager*	*Nobb-nr.*
47427236	MATAKI ASFALT FUGEMASSE 0,3LTR		2,00	TUB	0	207,20	10	47427236

Dato: _____ / _____ / _____ Sign:

XL-BYGG KÅRE ABELSEN AS har salgspant i solgte varer inntil kjøpesum med tillegg av rente og omkostninger i sin helhet er betalt. Etter forfall beregnes renter i henhold til lov om forsinket betaling.
Reklamasjon må skje skriftlig til firmapost@abelsen.no ved varens mottagelse. Varer selges ihht. XL-BYGG KÅRE ABELSEN ASs til enhver tid gjeldende salgs og leveringsbetingelser som er tilgjengelig på xl-bygg.no



NTNU

Kunnskap for en bedre verden