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Adaptive reuse of industrial heritage building – comparative life cycle assessment using a case study

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Abstract. Materials production dominates the total Greenhouse gas (GHG) emissions in the construction industry. On the other hand, most existing building stocks are expected to last for the next 30 years, which can contribute to increasing resource efficiency, reducing environmental impact, and creating social, cultural, and economic values for society. Therefore, it becomes vital to investigate the environmental impacts of adaptive reuse of existing buildings using a life cycle approach. The objective of this study is to explore the environmental performance of adaptive reuse of an industrial heritage building compared to new construction using a life cycle assessment (LCA) method. The environmental impacts of the selected case study are evaluated using four scenarios, with two adaptive reuse scenarios, a warehouse or an office building and two new construction scenarios, a new warehouse or a new office building. One-Click LCA is used as an LCA tool, and the scenarios are compared by total carbon footprint, life cycle models, GHG emissions per building elements and material types. The results show that among the four scenarios, the adaptive to warehouse scenario is the best adaptation option with considerably lower environmental impact, followed by the adaptive office scenario. This paper highlights that adaptation of existing industrial heritage buildings, with the least materials replacement option, is worthwhile. The further evaluation needed for the study's limitation is also highlighted for data efficiency and potential for further research. **Keywords:** Adaptation reuse; Case study; Circular economy; Industrial heritage building; Life cycle assessment; Norway.

1. Introduction

The existing building stock in every city has aged in recent years. 80% of the existing building stock in Norway will still be used beyond 2050 [1]. Today, about 36% of global energy consumption and 39% of greenhouse gas (GHG) emissions are caused by the construction sector [2]. Moreover, the waste from the construction industry can severely impact the environment and result in resource depletion. In Norway, building and construction waste represented about 25% of the national waste. The waste from demolition and new construction accounts for ca. 75% of the total building and construction waste [3]. In recent years, rehabilitation and adaptive reuse of existing building stock, including industrial heritage buildings, has become a trend in the construction industry [4]. The driving force is the potential for reducing GHG emissions and increasing resource utilisation in the construction industry.

In this context, rehabilitation and adaptive reuse of the existing building must be intensified to minimise emissions by adapting old or new purposes. Some old buildings have got the title of cultural heritage. One way to sustain these cultural heritage buildings is to adapt them to contemporary uses [5]. While adapting the buildings, different parameters, such as architectural preservation and structural reconstruction, should be considered. Some authors considered social, economic, environmental, and political-institutional parameters and called the holistic approach to sustainable renovation [6]. In addition, sustainable building renovation improves the quality of the user's life, for example, indoor climate, energy efficiency, and affordable housing price. However, there is a challenge in collecting reliable data for the evaluation of the actual performance of the buildings due to outdated materials and construction techniques.

The purpose of this study is to evaluate how adaptive reuse of industrial heritage buildings can reduce the environmental impacts compared to building new by preserving the materials and historical values of the building. The objective is to explore the carbon footprint of adaptive reuse of an industrial heritage building as a case study using an LCA approach. Four scenarios are considered to investigate the studied case study: adaptive warehouse, adaptive office, new warehouse, and new office. One-Click LCA is used as an LCA tool. The paper is structured as follows. Section 2 describes the definitions and status of LCA studies on heritage buildings. Section 3 presents the research methodology, including the case study description, LCA approach, scenarios, inventory, and data sources. The results of the applied approach are presented in section 4, followed by the main contribution and limitations discussed in section 5. The paper concludes in section 6.

2. Definitions and state of the art of LCA to assess heritage buildings

The definition of terms and the methods used in this study are defined below as background information.

2.1 Adaptive reuse and rehabilitation

The terms rehabilitation and adaptive reuse are sometimes interchangeable, even if they have different strategies and scopes. According to [7], the significant difference between adaptive reuse and rehabilitation is the building's purpose. The building's use is changed in adaptive reuse but not in rehabilitation. Adaptive reuse is the process of extending the service life of the building using an alternative strategy by remaining the basic structure intact and changing its use [8]. Rehabilitation is reusing an existing building by repairing, altering, or adding to a deteriorating building to continue its use or to make it compatible with its current use [7]. This study is limited to the adaptive reuse of an industrial heritage building.

2.2 Cultural and industrial heritage buildings

Cultural heritage includes buildings, artworks, architectural monuments, natural monuments and areas with historical, aesthetic and architectural significance [9]. Heritage buildings are also categorised by their value (physical, environmental, social and economic) and types (based on their archaeological, built, landscape, movable-collection, and conservation area) [9]. Several cultural heritage buildings are standing nowadays, with remarkable memories of society and history. At the same time, there are some industrial heritage buildings in the building stock with both social and industrial historical values. Since 1970, industrial buildings in developed countries have been abandoned due to the changes in the manufacturing industry [7]. Most manufacturing has been moved from developed countries to developing countries due to the cost of manufacturing. Since then, several industrial buildings in developed countries have been abandoned and dilapidated eventually [7]. Some of these industrial buildings are preserved as industrial heritage buildings adapted for different purposes [10] since the original purpose could not be retrieved.

2.3 Life cycle assessment (LCA)
Life cycle assessment (LCA) is a systematic method to quantify the environmental impacts of buildings, materials and products throughout their life cycle [11], [12]. The basic LCA principles, as outlined by ISO 14044:2006 [13] and 14040 [14], are conducted in four stages: the goal and scope definitions, the inventory analysis, the impact assessment, and the interpretation. The scope definition includes the system boundary and level of detail. The System boundary is a set of criteria specifying which unit processes are part of a product system. The whole building LCA followed NS-EN 15978-2011 [15] and NS 3720-2018 [16], and the environmental declaration for construction products is according to EN 15804:2012 [17]. LCA studies showed that adaptive reuse and rehabilitation of heritage buildings have lower environmental impact over their life cycle and can be alternatives to new low-energy buildings [12]. However, the lack of research on LCA of the adaptive reuse and rehabilitation of industrial heritage buildings shows that several industrial buildings have been adapted without sufficient information. The current implementation of adaptive reuse relies on descriptive approaches with a small quantity of objective measurement that depends on the intuition and experience of practitioners [18]. Intuition planning often leads to sub-optimal plans.

3. Methodology
The methodology in this study includes a description of the case study, the LCA methodology, the scenarios considered, and the background studies of life cycle inventory data.

3.1 Case study description
The case study considered is an industrial heritage building (PM5) built between 1881-1883 and located in Skien, Norway (Figure 1). According to Vestfold and Telemark municipality, PM5 means Paper Machine No.5 [19]. PM5 was built with cast-iron columns, stone, brick, and masonry during the second industrial revolution.

Figure 1:Case study- Industrial heritage building -PM5

The original purpose of PM5 was to produce wood pulp (cellulose) and eventually be used for paper production. In 1958, the paper machine was removed due to more extensive and advanced machines in the production industry. This building was built with cast-iron columns, stone, brick, and masonry during the second industrial revolution. Then, the PM5 became a warehouse for paper production. However, the PM5 was abandoned for about 50 years (according to the project developer). The Norwegian Directorate has preserved PM5 for Cultural Heritage (Riksantikvaren) under the heritage act: kulturminneloven §§16-20 [21]. It is also the oldest preserved among Union's factory buildings in Norway [20].

3.2 Goal and scope of the study
This study aims to evaluate the environmental impact of the adaptive reuse of PM5. The system boundary includes the life cycle modules A1-A3 (production stage), A4-A5 (construction stage), B4 (replacement), B5 (refurbishment), C1-C4 (End of life cycle) and D (benefits and loads beyond system boundary) following NS 3720. The operational energy use (B6) is not included as the study focuses only

on embodied emissions. The environmental impact assessments of defined scenarios were performed by using the OneClick LCA tool.

3.3 Scenario description

Four scenarios are evaluated to compare the environmental impacts of PM5, and each scenario is defined according to the targeted building's purpose and life cycle stage. The scenarios are described below and summarised per life cycle stages under Table 1.

Scenario 1: Adaptive warehouse: adaptive reuse of the PM5 as a warehouse. An assumption of improving the building performance with additional insulation and other necessary components such as doors and windows, plastering, painting, replacing the missing brick, and repairing the floor screeding are considered.

Scenario 2: Adaptive office: the same as scenario 1, but the adaptive reuse of PM5 to an office building is considered by adding internal walls to divide the office cubical. Additional materials for internal walls with timber frame, insulation, doors, and windows, plastering, painting, replacing the missing brick, and repairing the floor screed and finishes are considered.

Scenario 3: New warehouse: rebuilt a new warehouse after demolishing PM5. The new warehouse building design and inventory were according to the One Click LCA's reference building for the warehouse with the same gross floor area and the number of floors as the PM5.

Scenario 4: New office: rebuilt a new office building after demolishing the PM5. The new office building design and inventory were taken from One Click LCA's reference office building.

In all scenarios, the environmental impacts from additional materials and components are considered, whilst existing materials are considered carbon natural.

Table 1: System boundary for scenarios of the studied case

System Boundary NS-EN 15978:2011																	
Module	A1-A3			A4-A5		B1-B7							C1-C4				D
Life cycle stages	Product Stage			Construction process stage		Use stage							End-of-life stage				Benefits and loads beyond the system boundary stage
Processes	Raw material supply	Transport	Manufacturing	Transport	Construction- installation process	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	Deconstruction/demolition	Transport	Waste processing	Disposal	Reuse, recovery, and recycling potential
	A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
Once-Click LCA																	
Adapted Warehouse				√	√				√	√			√	√	√	√	√
Adapted Office				√	√				√	√			√	√	√	√	√
New Warehouse	√	√	√	√	√				√	√			√	√	√	√	√
New Office building	√	√	√	√	√				√	√			√	√	√	√	√

3.4 Inventory and data sources

A critical point in performing LCA is to get precise information and consistency between inventory data and background databases [23]. Inventory analysis is a technical process of collecting data to quantify the inputs and outputs of the system, as defined in the scope [24]. Thus, the result of an inventory analysis is a list of the total inputs from nature (resource materials or energy) and emissions to air. The result of the LCA can be presented in different environmental impact indicators. Global warming potential (GWP) expressed in tCO_2eq is considered the only indicator in this study.

The inventory data is collected using different methods and tools. Due to the lack of information, determining the building's components' assemblies was challenging. After studying the possibility of assemblies and materials, the Bill of Materials (BOM) for existing materials was calculated conventionally using the PM5 drawings obtained from the project developer and some assumptions were considered. The developer of PM5 confirmed that the building's integrity is stable. Therefore, no structural assessment of the PM5 was considered, and the building was repaired under the adaptive reused strategy. The construction techniques of the 19th century were studied as the PM5 was built in the 19th century. During the 19th century, concrete masonry was widely used for industrial buildings. The first concrete building with reinforced steel rods was built in England in the mid-19th century [25]. According to [26], the concrete design was a rather arbitrary procedure with no guidelines before the Design of Concrete Mixtures was published by Abrams in 1919. Louis Carlton Sabin stated that one should consider concrete as a volume of aggregate bound together by a mortar of the proper strength in 1905 [27]. Joseph Aspdin invented Portland cement in 1924 [28]. Based on these facts, the assumption was made that the PM5 was built with portland cement motor with aggregate reinforcement. However, the cement ratio follows the concrete component from 'The Portland Cement Association (PCA) [29].

The additional products for the adaptive reuse scenarios are: 1) the outer walls\ plastering is replaced and repainted on the outer side, 2) insulation and gypsum board are added to achieve adaptive purposes, 3) floor screeding was repaired, 4) doors and windows were replaced with new products, 5) a new staircase was installed, 6) internal walls were added in adaptation to office scenarios. The input data of PM5 materials are shown in Appendix A1. The existing materials are considered carbon neutral and not included in the evaluation. The service life of the PM5 is assumed to extend 100 years. The replaced materials' lifespan followed the products\ EPD data, and OneClick LCA automatically calculated the replacement during the new building lifespan. The bill of materials for new building scenarios (new warehouse and new office) is according to the OneClick LCA's carbon designer reference building.

The data is extracted and shown in Appendix A2. Since developers do not provide the replaced materials EPD, the study uses One Click LCA generic data in adaptive scenarios (adaptive warehouse and adaptive office). The One Click LCA web tool also confirms that One Click LCA generic materials are intended for use when no sourcing decisions have been made, and no locally applicable generic profiles are available [30]. On the other hand, EPD data of the new scenarios is according to the reference building of One Click LC. The resource material used in all scenarios is shown in Appendix A1 and A2.

4. Results

In this section, the GHG emission results of each scenario are presented per life cycle modules, total carbon footprint, by building elements and material types.

4.1 Total carbon footprint

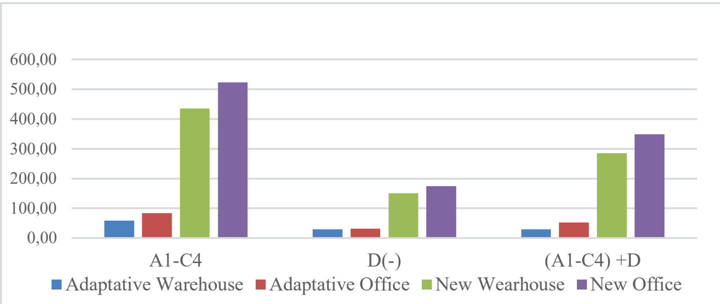

Figure 2: GHG emission for A1-C4, D and A1-D

The results of the total GHG emissions are shown in Figure 2, which presents the total emission of modules A1-C4, module D1 and total emission including module D. The adaption to the warehouse scenario is the one with the lowest total carbon footprint (59 tCO_2eq), and the GHG emission of the new office is 523 tCO_2eq). Module D positively impacts the environment and subtracts from the A1-C4 GHG emissions. Adaptive scenarios reduced more than 80% of the total GHG emissions, including and excluding module D, than new scenarios.

4.2 GHG emission per life cycle modules

The GHG emission results per life cycle modules are presented in **Figure *3***. The results show that the production phase of new construction scenarios (A1-A3) has the most significant impact. The new office scenarios have the highest GHG emissions from all life cycle modules, and the adaptation to the warehouse scenario has the lowest GHG emissions. By adapting to new purposes, all modules save emissions significantly. The adaptive warehouse scenario reduced more than 84% of GHG emissions, and the adaptive office scenario reduced at least 75%.

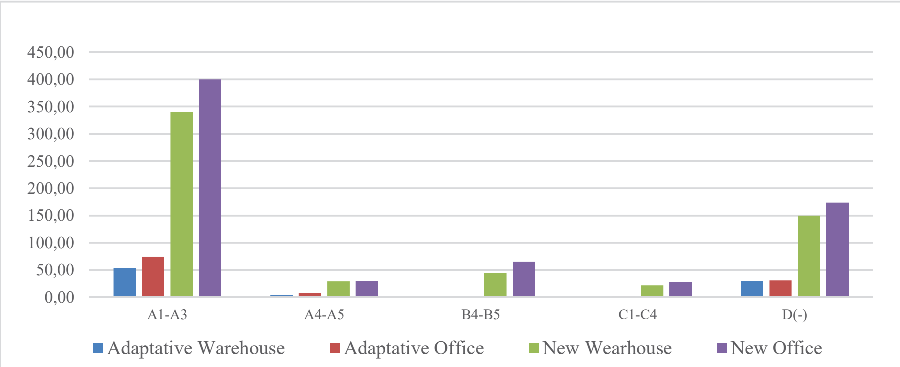

Figure 3: GHG emission by Life cycle modules (A1-A3, A4-A5, B4-B5, C1-C4 and D)

4.3 GHG emission results per building elements

Figure *4* shows the GHG emission results per building element. The main GHG emission contributors are the floor, ceiling, roof and other elements of new scenarios. The GHG emissions were reduced by 76% (floor) and 100% (ceiling and roof) in the adaptive warehouse scenario, and 82% (floor) and 75% (ceiling) and 100% (roof) in the adaptive office scenario. Though the impacts are insignificant, the columns and beams in adaptive scenarios save almost 100% of GHG emissions. At the same time, the adaptation scenarios save over 15 tCO_2eq (60%) for external walls and 17.4 tCO_2eq for internal walls. Moreover, the other elements of adaptation scenarios cut down 65.7 tCO_2eq for the warehouse and 108.7 tCO_2eq for the office.

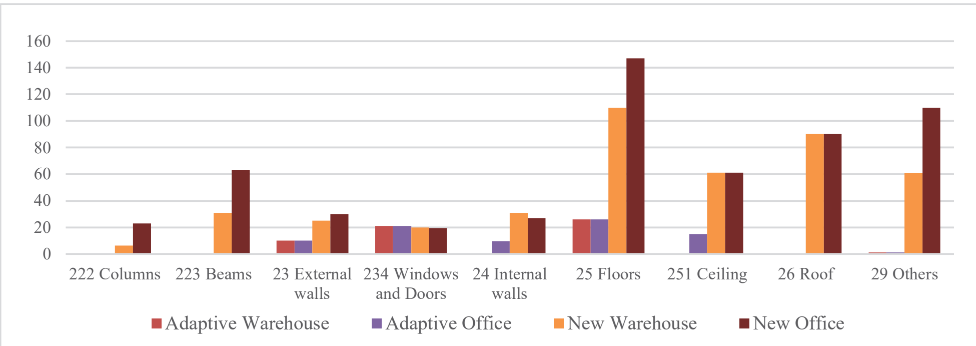

Figure 4: GHG emission by building elements

4.4 GHG emission per material type

The GHG emission results of each scenario per material type are shown in **Figure 5**. Concrete is the one with the highest GHG emission for the new scenarios (with 242 tCO_2eq in the new warehouse and 225 tCO_2eq in new office scenarios), followed by metal (61 tCO_2eq in the new warehouse and 118 tCO_2eq in the new office), bitumen (38 tCO_2eq in both new scenarios) and insulation (36 tCO_2eq in new warehouse and 38 tCO_2eq in new office) with considerable impacts.

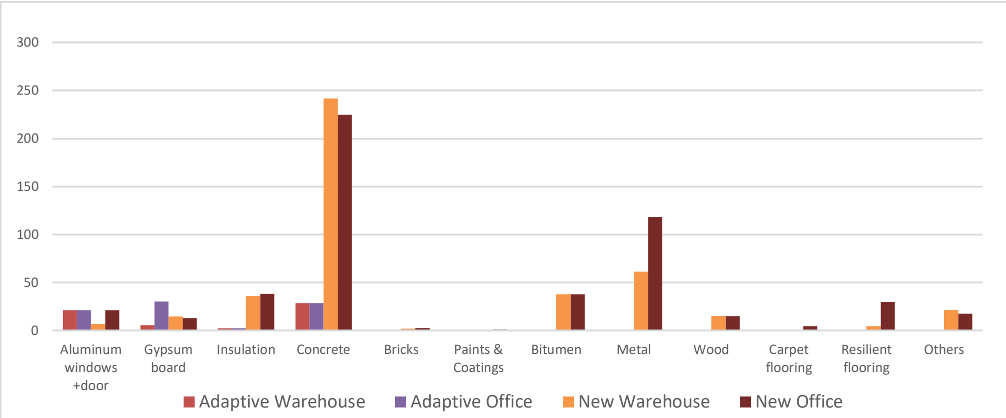

Figure 5: GHG emission by resource types

However, the GHG emissions from aluminium windows used in the adaptation buildings (21 tCO_2eq) are higher than in the new warehouse building (7 tCO_2eq) due to the more oversized doors and total windows area of the existing buildings compared to the new warehouse. The GHG emission from the gypsum board in the adaptation office (30 tCO_2eq) is 17 tCO_2eq higher than the new office scenario for additional interior walls. Therefore, the adaptation scenarios are better than the new scenarios for both the warehouses and offices.

5. Discussion

The results from this study show that adaptative scenarios (adaptive warehouse and adaptive office) have considerably lower GHG emissions due to the carbon offset from the existing materials. The GHG emission from the adaptive office scenario is slightly higher than the adaptive warehouse scenario considering internal partitions and insulation in the adapted office scenario to get a better indoor environment. Here it should be noted that the scenario excluded other building elements (e.g., fixed inventory, heating, ventilation, and sanitation). Therefore, the GHG emission of an adaptive office building might have higher impacts. Moreover, the floor finishes of the adaptive scenarios considered conventional screeding methods. Consideration of sustainable floor finish products (for example, recycled materials wood floor) is used; the adaptive scenarios might have lower emission results.

Environmental impacts of the heritage building are an indecisive matter for the building stock. For example, industrial buildings were built with concrete masonry worldwide during the industrial revolution. Some of these buildings, built in the early 19th century, have been titled industrial heritage buildings by UNESCO (United Nations Educational, Scientific and Cultural Organization). Therefore, these buildings are essential to reserve and reuse them. All countries have their historical identity to preserve existing industrial heritage buildings for the next generation. In addition, the environmental impacts of the land used, natural resources extraction, time, and construction costs can be reduced by adapting the industrial heritage buildings. The extended service life of these buildings can contribute towards carbon-neutralised construction.

On the other hand, new construction materials and elements should be constructed with longer service life. Reusing the structural elements of the industrial heritage building with the replaced materials is reasonable for the built environment. Instead of building with structural elements with a shorter lifetime, the future building should build with durable materials which have a longer service life. In addition, the building structure should be easily customised according to the future user's preferences. This method will reduce the impacts and costs related to deconstruction and reconstruction.

Moreover, the materials specifications and environmental data must be recorded well. Collecting data from the case study has a major challenge in identifying the materials, assembly, and specification of the materials used, resulting in using some assumptions. This challenge can be further studied during the actual PM5 adaptation process. The current databases (for example, ecoinvent) are a collection of modern materials and elements.

This study emphasised that the adaptive reused design with minimal additional materials (adaptive warehouse scenario) is the most favourable design for the industrial heritage building (PM5). Usually, most adaptive reused buildings consider mainly energy and architectural aspects due to the assumption that environmental aspects have already been saved by adapting the building (without demolition or reconstruction). However, additional materials might be needed to improve indoor air quality, ventilation, and thermal comfort. Thus, conducting an LCA will enable quantifying and evaluating the benefits and impacts. This LCA will enable stakeholders to decide whether to demolish or reuse, using LCA results.

Moreover, hazardous materials can be found in some industrial buildings. Therefore, the toxicity condition of the building must be accounted for in the building adaptation and environmental assessment. The LCA study should also be expanded to include cost and other social aspects and cover other environmental indicators than the GHG emission to get a holistic overview.

6. Conclusion

In recent years, environmental sustainability has been one of the most discussed issues in society. Reusing the existing building and products is an important aspect. In this paper, the embodied GHG emission from industrial heritage building (PM5) was conducted with two adaptive reuses to warehouse and office scenarios in comparison with the new warehouse and office construction scenarios. The outcome of this study enhances the knowledge of holistic evaluation of the environmental impact of industrial heritage buildings and highlights that adaptation with the least materials replacement option is worthwhile. Even if the existing database supports the environmental assessment of the heritage building using the LCA method, the study also highlighted the need for a database for the bill of quantities of the existing building stock. Moreover, adaptive reuse of existing buildings should consider designing the buildings to be customised with good integrity of the current and future needs of users and the use of durable materials. The operational emission with feasible energy calculation of the case study can be evaluated as future research.

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Appendix A1

Table 2: Materials Resources of Adaptive Scenarios (Unit in Kg)

Resourse	Adaptive Warehouse	Adaptive Office
Aluminium frame window, 24.27 kg/m2, 2.3 m2/unit (Organisation professionnelle représentative des concepteurs, fabricants et installateurs de menuiseries extérieures en profilés aluminium)	6400	6400
Clay bricks, masonry, 1970 kg/m3, Kingscourt Brick (Breedon Brick Ltd, Drumgill plant)	19700	19700
Emulsion facade paint, 1.0-1.7 kg/l (DBC, IVK, VdL)	85	85
Precast concrete part, staircase, 1,1 m wide, 9 steps each 16 cm, 1965 kg/unit	4	4
Fiber reinforced, self-leveling cement, 10 - 100 mm, 1600 kg/m3, Proplan Basic (Heydi)	129504	129504
Glass wool insulation panels, unfaced, generic, L = 0.032 W/mK, R = 3.13 m2K/W (18 ft2°Fh/BTU), 50 kg/m3 (3.12 lbs/ft3), (applicable for densities: 25-50 kg/m3 (1.56-3.12 lbs/ft3)), Lambda=0.032 W/(m.K)	6375	675
Gypsum plasterboard, 12.5x900/1200 mm, 8.8 kg/m2, Normal Plasterboard 12.5 mm, GNE/GN13 (Gyproc)	20000	54000
Interior paint, 1.45 kg/l, CapaSilan (CAPAROL)	234	234
Lime cement mortar, 1800 kg/m3	4496	4496
Masonry mortar, 1500 kg/m3, EPD coverage: >1500 kg/m3 (IWM)	23115	23115
Mixed aluminium/PVC frame windows and patio doors, DONNEE PAR DEFAUT (DED)	190	190
Wooden stud framing system for internal walls per sq. meter (incl. air gaps per m3), 39x66 mm, 600 mm spacing (Treindustrien)	0	1000

Appendix A2:

Table 3: Materials Resources of New Construction Scenarios (Unit in Kg)

Material resources	New warehouse	New office
Aluminum profile for windows and doors, 2600 kg/m3, Al Profile (Saray)	136	136
Bitumen sheets for waterproofing of roofs, French average, ép. 2,5 mm par couche, DONNEE PAR DEFAUT (DED)	6804	6804
Bricks, 226x104x60, 226x85x60 mm, NF with holes & solid, RF (Wienerberger)	37968	47589
Cement-composite façade panel, grey, coated,, 8-12 mm, Swisspearl (FibreCem Holding)	7000	3800
Ceramic wall tiles, 7.5 mm, 3000 kg/m2 (Seranit Granit Seramik)	20520	1700
Concrete (Norwegian low-carbon), B35 M45/MF45, lavkarbonklass B (2015 NB37)	842988	756707
EPS Insulation, T: 10-2400 mm, 600 x 1200 mm, 0.031 W/m2K, 16 kg/m3 (EPS-gruppen)	6864	6874
Finishing wall mortars, French average, 3 mm, 4.2 kg/m2, DONNEE PAR DEFAUT (DED)	17934	1941
Float glass, single pane, generic, 3-12 mm (0.12-0.47 in), 10 kg/m2 (2.05 lbs/ft2) (for 4 mm/0.16 in), 2500 kg/m3 (156 lbs/ft3)	9060	9060
Glass wall partitioninig system, 2400x2700x75mm, 6.48m2, 165kg, Flush Front System Wall 75 (Moelven Modus)	1422	7400
Glass wool insulation panels, unfaced, generic, L = 0.031 W/mK, R = 3.23 m2K/W (18 ft2°Fh/BTU), 25 kg/m3 (1.56 lbs/ft3), (applicable for densities: 0-25 kg/m3 (0-1.56 lbs/ft3)), Lambda=0.031 W/(m.K)	1800	2400
Glass wool, acoustic ceiling panel, 20 mm, 4.0 kg/m2, Master Rigid Dp (Ecophon)	13036	19048
Gypsum plaster board, regular, generic, 6.5-25 mm (0.25-0.98 in), 10.725 kg/m2 (2.20 lbs/ft2) (for 12.5 mm/0.49 in), 858 kg/m3 (53.6 lbs/ft3)	42960	38750
Hollow core concrete slabs, generic, C30/37 (4400/5400 PSI), 0% (typical) recycled binders in cement (300 kg/m3 / 18.72 lbs/ft3), incl. Reinforcement	560952	560952
Masonry mortar, light, 1000 kg/m3 (quick-mix)	18938	14265
Massive wooden flooring/parquet, 22-450 x 44-7000 x 8-35 mm, 11.71 kg/m2 (Verband der Deutschen Parkettindustrie)	5400	2700
Multifunctional steel door, product group 1, 1000mm x 2125 mm, H 3 D, H 3 OD, H 3 VM, H 3 KT, RS 55, D 65 OD, D 65 (Hörmann)	650	650
Perforated light weight aggregate concrete block, 200 x 250 x 500 mm, 770 kg/m3, Leca Universalblokk (Weber)	61328	9086
Planed timber, conifer (Treindustrien)	8130	7101
Plastic vapour control layer, 0.2 mm (Tommen Gram)	459	409
Reinforcement steel (rebar), generic, 90% recycled content, A615	33017	34424
Self levelling mortar, for floors, walls and overhead appl., 3-50 mm, 1400 kg/m3, Pericret (PCI Augsburg)	42336	42336
Structural hollow steel sections (HSS), cold rolled, generic, 10 % recycled content, circular, square and rectangular profiles, S235, S275 and S355	15988	37698
Tile adhesive, all round, for ceramics, 1-5 mm, 1400 kg/m3, Verlegemörtel (PCI Augsburg)	1197	99
Vinyl flooring, Be Natural Be Different Be easy Be Smart (DICKSON-CONSTANT)	230	230
Water-borne interior paints, 1.36 kg/L, average coverage 8-10 m2/L, Biora, Ekora, Kolibri Sand, Paneelikattomaali, Ranch, Superlateksi, Tapettipohjamaali, Teknospro, Tela, Timantti, Trend (Teknos)	439	530
Waterproof, protective, flexible coating, 1.5 kg/l, Lastogum (PCI Augsburg)	1300	110
Wooden decking, cladding and planed timber for joinery applications, 540kg/m3, Moistr. 3-5%, Accoya Scots Pine (Accsys Technologies PLC)	1812	1812
Wooden entrance door, per m2, 809x2053 mm, 42x92 mm frame, 52 mm door leaf (Nordic Dørfabrikk)	2300	3000
Woven wall-to-wall carpet, PA 6, textile fabric backing, 0.5-0.6 kg/m2 pile weight, Sigma WT (Bentzon Carpets)	NA	2100