Prototype Commercial Building

Full building summary

7/19/2023

Table of Contents

Report Summary

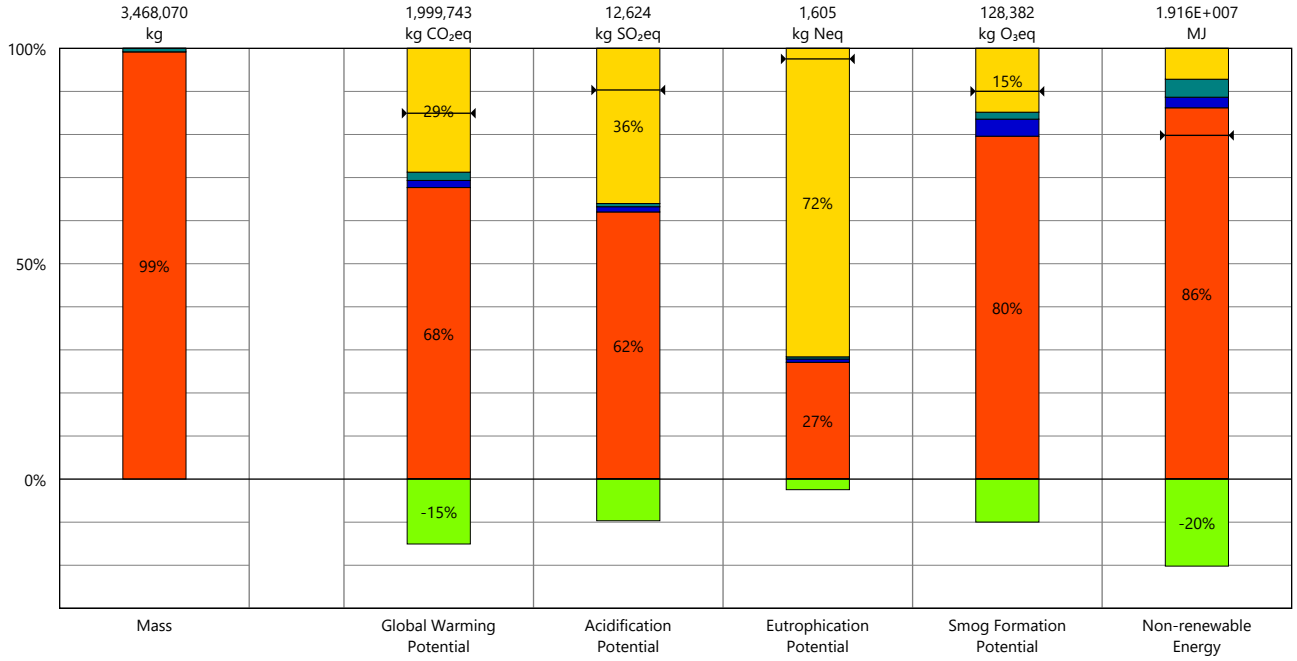
Created with Tally
Non-commercial Version 2022.04.08.01

Author	mchaf
Company	Carbon Leadership Forum
Date	7/19/2023
Project	Prototype Commercial Building
Location	M3.1
Gross Area	67500 ft^2
Building Life	60 years
Boundaries	Cradle to grave, exclusive of biogenic carbon; see appendix for a full list of materials and processes

Goal and Scope of Assessment
Goal: To assess carbon impacts of a prototypical commercial building

Environmental Impact Totals	**Product Stage [A1-A3]**	**Construction Stage [A4]**	**Use Stage [B2-B5]**	**End of Life Stage [C2-C4]**	**Module D [D]**
Global Warming (kg CO_2eq)	1,353,419	33,016	38,457	574,851	-301,299
Acidification (kg SO_2eq)	7,829	153.8	93.63	4,548	-1,221
Eutrophication (kg Neq)	435.2	12.53	7.935	1,150	-39.5
Smog Formation (kg O_3eq)	102,191	5,083	2,073	19,035	-12,806
Ozone Depletion (kg CFC-11eq)	0.06036	1.137E-009	1.231E-008	1.814E-008	4.786E-004
Primary Energy (MJ)	2.897E+007	482,776	843,293	1,466,772	-6,017,427
Non-renewable Energy (MJ)	1.652E+007	471,223	799,635	1,374,538	-3,871,242
Renewable Energy (MJ)	1.245E+007	11,674	43,226	92,901	-2,157,660
Environmental Impacts / Area					
Global Warming (kg CO_2eq/m^2)	215.8	5.265	6.133	91.67	-48.0
Acidification (kg SO_2eq/m^2)	1.248	0.02453	0.01493	0.7252	-0.1946
Eutrophication (kg Neq/m^2)	0.0694	0.001997	0.001265	0.1834	-0.006293
Smog Formation (kg O_3eq/m^2)	16.30	0.8106	0.3306	3.035	-2.04
Ozone Depletion (kg CFC-11eq/m^2)	9.626E-006	1.813E-013	1.963E-012	2.893E-012	7.632E-008
Primary Energy (MJ/m^2)	4,619	76.99	134.5	233.9	-960
Non-renewable Energy (MJ/m^2)	2,634	75.14	127.5	219.2	-617
Renewable Energy (MJ/m^2)	1,986	1.862	6.893	14.81	-344

Results per Life Cycle Stage

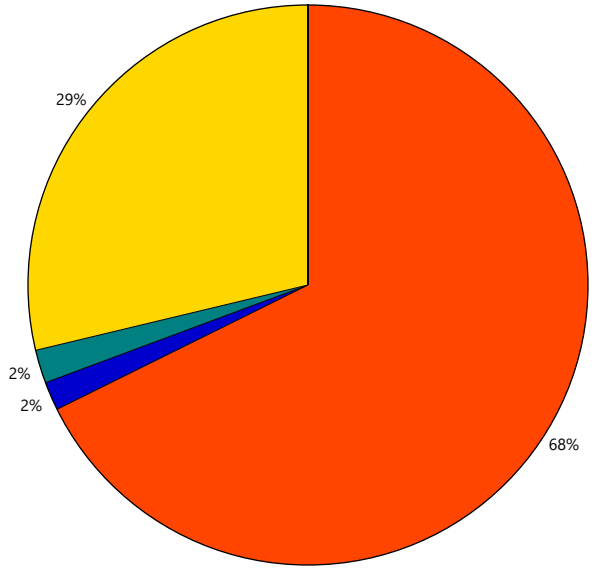


Legend

Net value (impacts + credits)

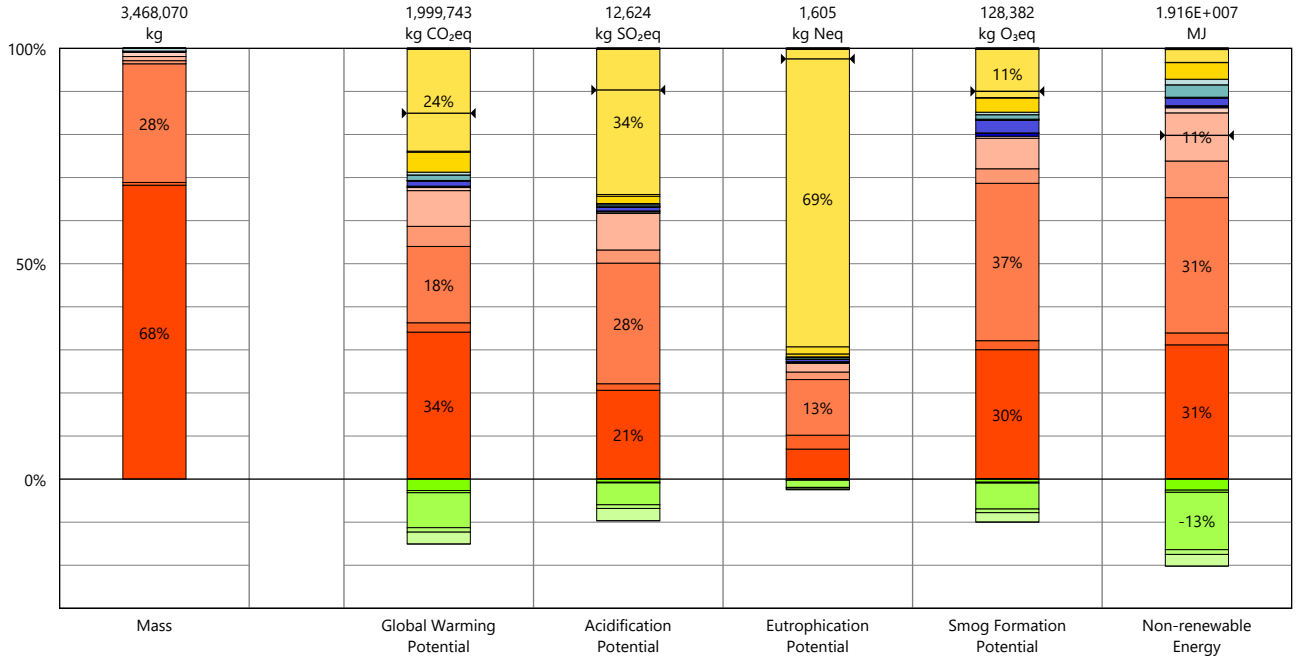
Life Cycle Stages

- Product [A1-A3]
- Transportation [A4]
- Maintenance and Replacement [B2-B5]
- End of Life [C2-C4]
- Module D [D]



Global Warming Potential

Results per Life Cycle Stage, itemized by Division



Legend

Net value (impacts + credits)

Product [A1-A3]
- 03 - Concrete
- 05 - Metals
- 06 - Wood/Plastics/Composites
- 07 - Thermal and Moisture Protection
- 08 - Openings and Glazing
- 09 - Finishes

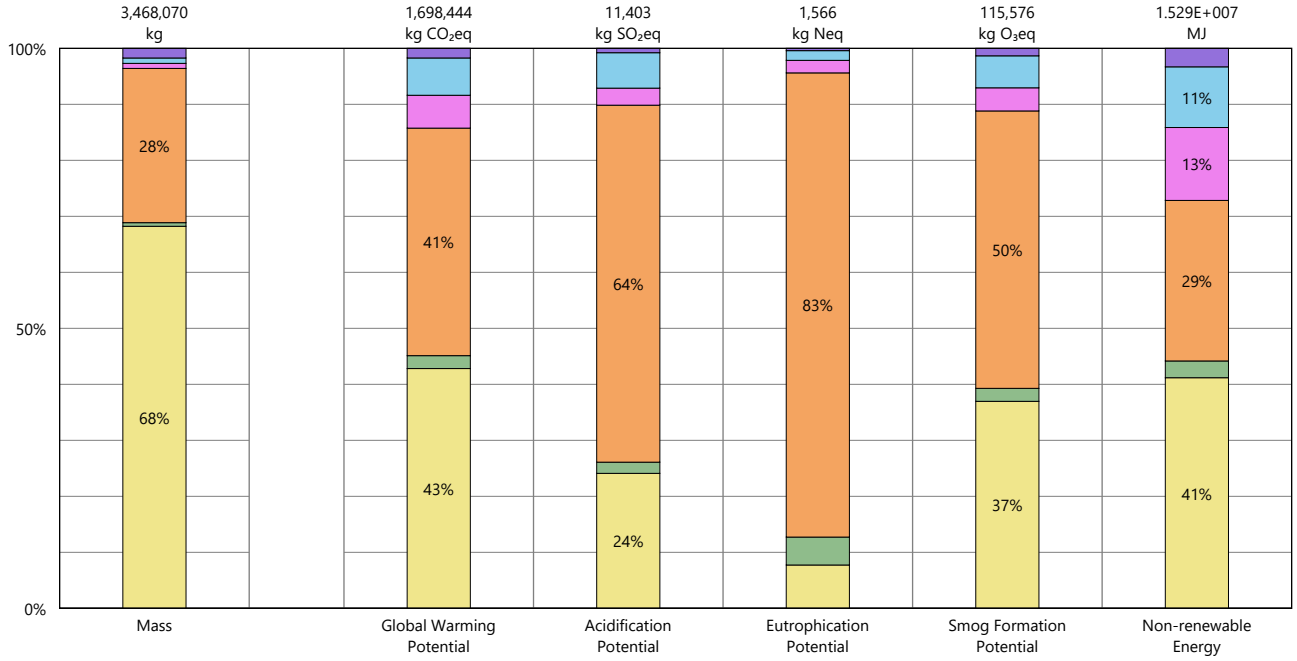
Transportation [A4]
- 03 - Concrete
- 05 - Metals
- 06 - Wood/Plastics/Composites
- 07 - Thermal and Moisture Protection
- 08 - Openings and Glazing
- 09 - Finishes

Maintenance and Replacement [B2-B5]
- 03 - Concrete
- 05 - Metals
- 06 - Wood/Plastics/Composites
- 07 - Thermal and Moisture Protection
- 08 - Openings and Glazing
- 09 - Finishes

End of Life [C2-C4]
- 03 - Concrete
- 05 - Metals
- 06 - Wood/Plastics/Composites
- 07 - Thermal and Moisture Protection
- 08 - Openings and Glazing
- 09 - Finishes

Module D [D]
- 03 - Concrete
- 05 - Metals
- 06 - Wood/Plastics/Composites
- 07 - Thermal and Moisture Protection
- 08 - Openings and Glazing
- 09 - Finishes

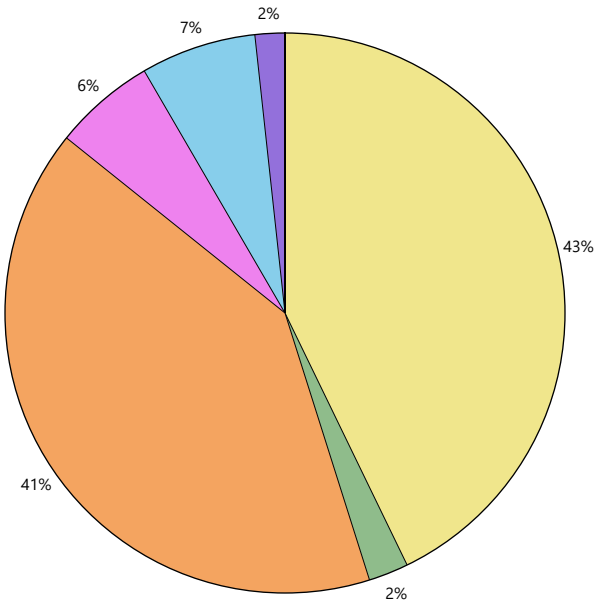
Results per Division



Legend

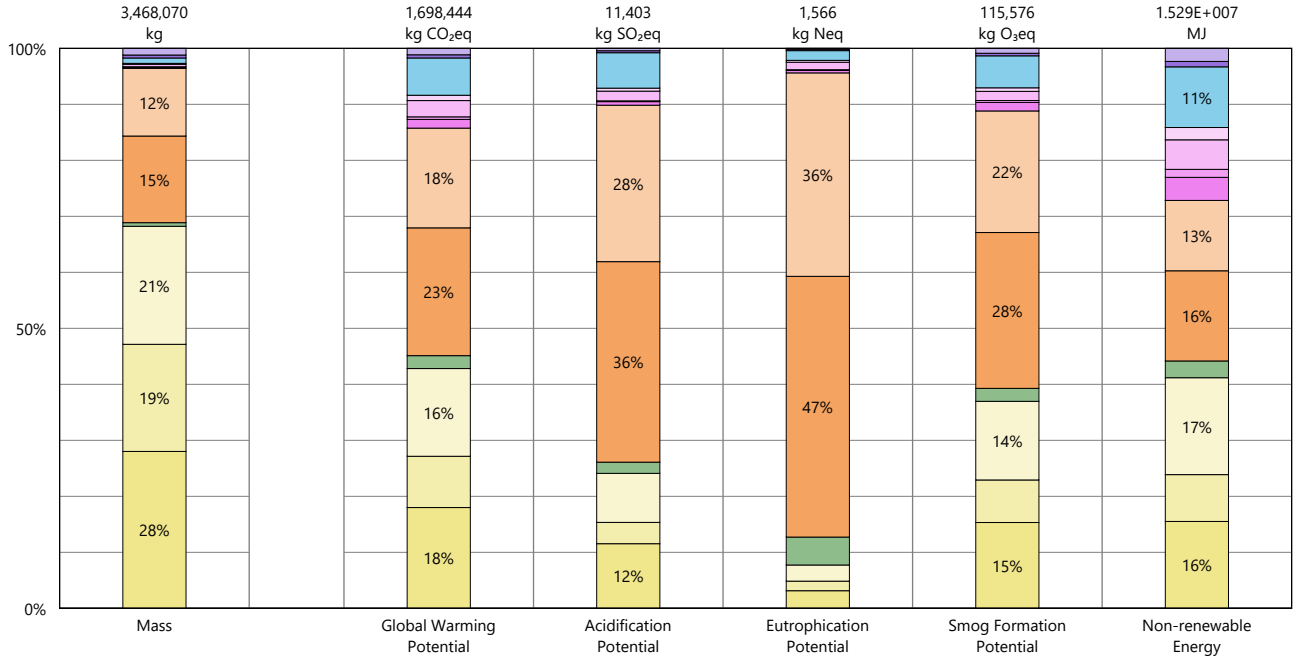
Divisions

- 03 - Concrete
- 05 - Metals
- 06 - Wood/Plastics/Composites
- 07 - Thermal and Moisture Protection
- 08 - Openings and Glazing
- 09 - Finishes



Global Warming Potential

Results per Division, itemized by Tally Entry



Legend

03 - Concrete
- Cast-in-place concrete, lightweight structural concrete, 3000 psi
- Cast-in-place concrete, structural concrete, 4000 psi
- Cast-in-place concrete, structural concrete, 6000 psi

05 - Metals
- Steel, C-stud metal framing with insulation

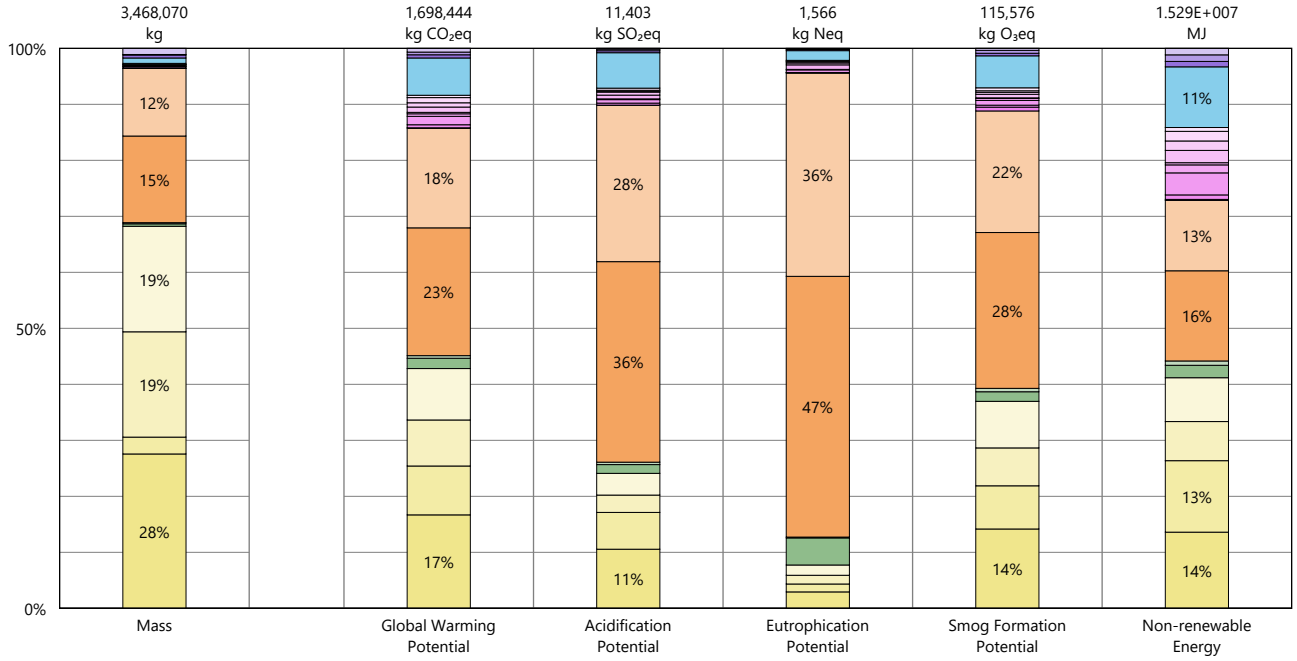
06 - Wood/Plastics/Composites
- Cross laminated timber (CLT)
- Glue laminated timber (Glulam)

07 - Thermal and Moisture Protection
- EPDM, roofing membrane
- Expanded polystyrene (EPS), board
- Insulated metal wall panel, custom
- Polyisocyanurate (PIR), board

08 - Openings and Glazing
- Curtainwall System (including glazing)

09 - Finishes
- Fiberglass mat gypsum sheathing
- Wall board, gypsum

Results per Division, itemized by Material



Legend

03 - Concrete

- Lightweight concrete, 3000 psi, 20% fly ash
- Steel, reinforcing rod
- Structural concrete, 4000 psi, 20% fly ash
- Structural concrete, 6000 psi, Pacific Southwest regional average

05 - Metals

- Cellulose insulation, boards
- Cold formed structural steel

06 - Wood/Plastics/Composites

- CLT (Cross laminated timber)
- Glue laminated timber (Glulam), AWC - EPD

07 - Thermal and Moisture Protection

- Adhesive, polychloroprene (neoprene)
- Aluminum, sheet
- EPDM, non-reinforced membrane, 60 mils, SPRI - EPD
- Expanded polystyrene (EPS), board
- Fasteners, stainless steel
- PIR rigid foam insulation, roof, R=15, PIMA - EPD
- Polyurethane foam (PUR) rigid board
- Powder coating, metal stock
- Steel, sheet

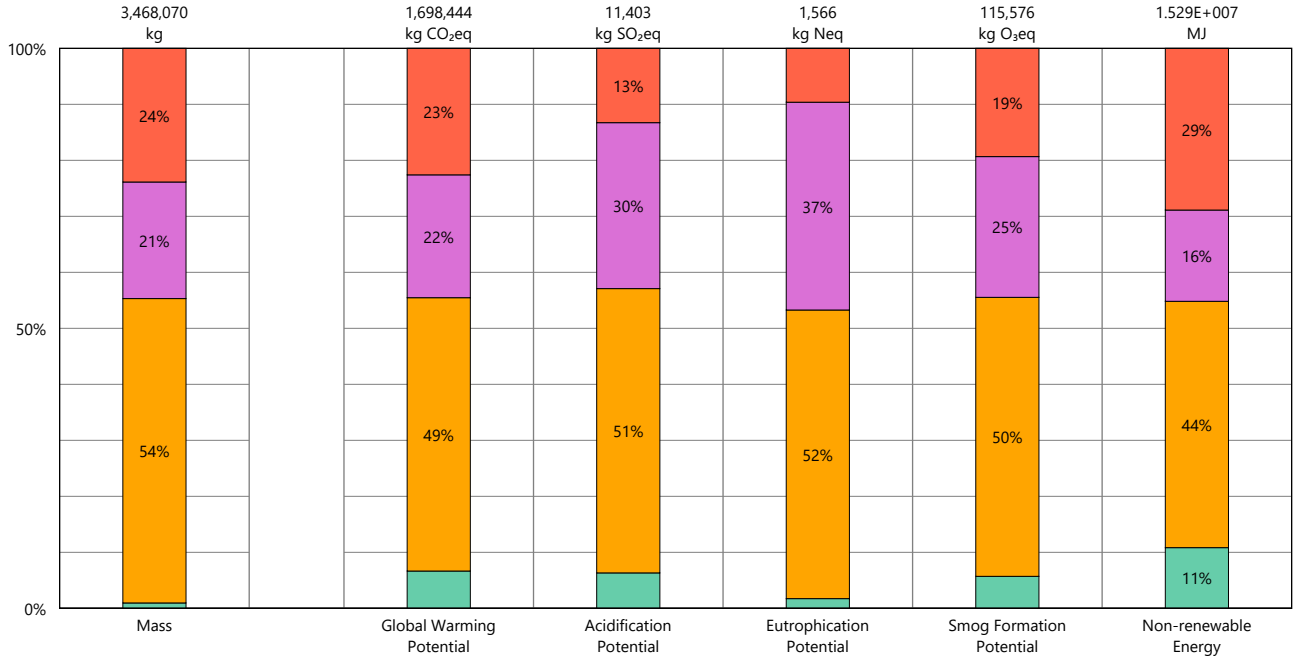
08 - Openings and Glazing

- Curtain wall system, Kawneer, 1600 Wall System - EPD

09 - Finishes

- Fiberglass mat gypsum sheathing board
- Paint, interior acrylic latex
- Wall board, gypsum, natural

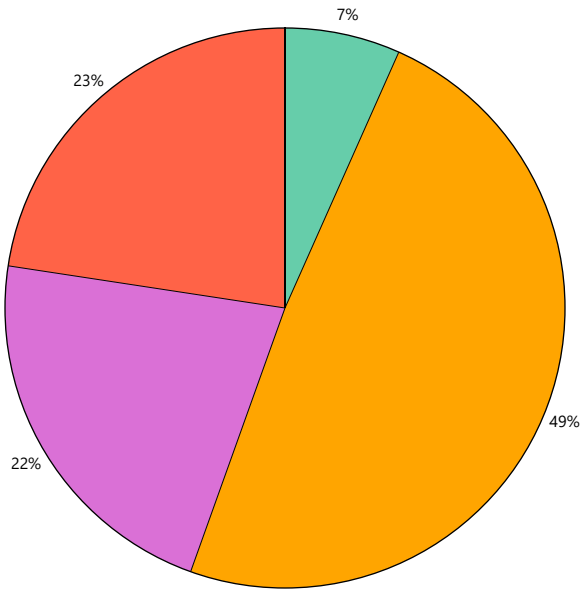
Results per Revit Category



Legend

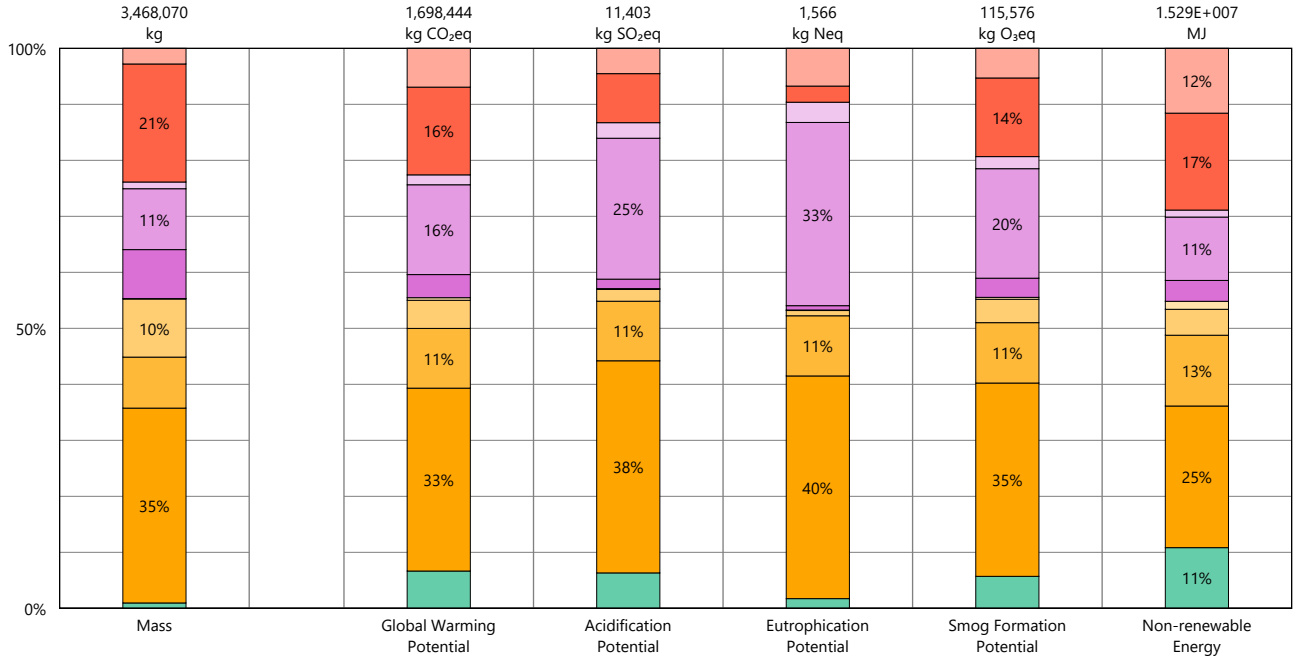
Revit Categories

- Curtainwall Panels
- Floors
- Structure
- Walls



Global Warming Potential

Results per Revit Category, itemized by Family



Legend

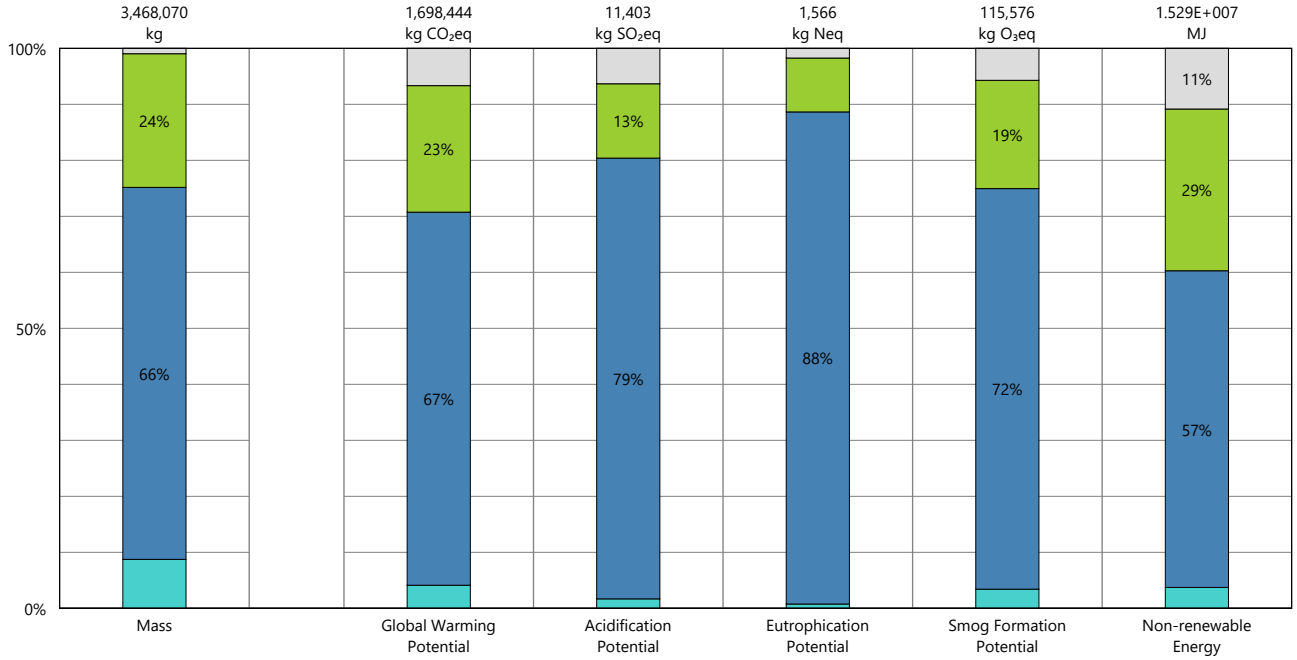
Curtainwall Panels
- System Panel

Floors
- CLT
- CLT Roof
- SOG Floor
- SOG Floor Insulation

Structure
- Footing-Rectangular
- Glulam-Southern Pine
- Glulam-Western Species-Column

Walls
- Concrete - 16"
- Generic - 5"

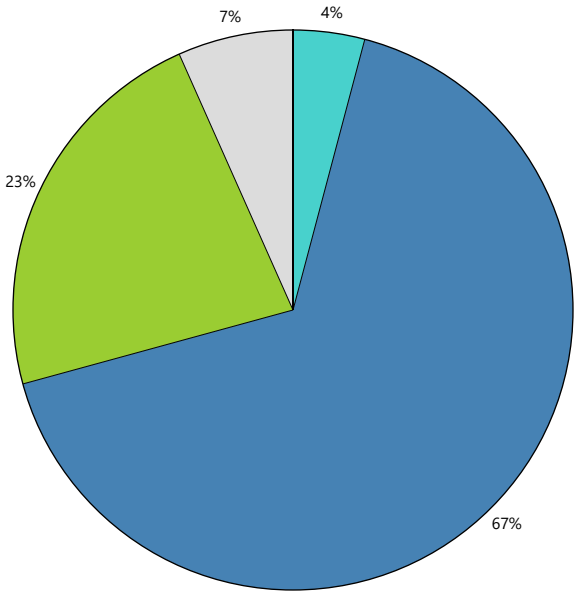
Results per Building Element



Legend

Building Elements

- Substructure
- Superstructure
- Enclosure
- Undefined



Global Warming Potential

Calculation Methodology

LIFE CYCLE ASSESSMENT METHODS

The following provides a description of terms and methods associated with the use of Tally to conduct life cycle assessment for construction works and construction products. Tally methodology is consistent with LCA standards ISO 14040-14044, ISO 21930:2017, ISO 21931:2010, EN 15804:2012, and EN 15978:2011. For more information about LCA, please refer to these standards or visit www.choosetally.com.

Studied objects

The life cycle assessment (LCA) results reported represent an analysis of a single building, multiple buildings, or a comparative analysis of two or more building design options. The assessment may represent the complete architectural, structural, and finish systems of the building(s) or a subset of those systems. This may be used to compare the relative environmental impacts associated with building components or for comparative study with one or more reference buildings. Design options may represent a full or partial building across various stages of the design process, or they may represent multiple schemes of a full or partial building that are being compared to one another across a range of evaluation criteria.

Functional unit and reference unit

A functional unit is the quantified performance of a product, building, or system that defines the object of the study. The functional unit of a single building should include the building type (e.g. office, factory), relevant technical and functional requirements (e.g. regulatory requirements, energy performance), pattern of use (e.g. occupancy, usable floor area), and the required service life. For a design option comparison of a partial building, the functional unit is the complete set of building systems or products that perform a given function. It is the responsibility of the modeler to assure that reference buildings or design options are functionally equivalent in terms of scope and relevant performance. The expected life of the building has a default value of 60 years and can be modified by the modeler.

The reference unit is the full collection of processes and materials required to produce a building or portion thereof and is quantified according to the given goal and scope of the assessment over the full life of the building. If construction impacts are included in the assessment, the reference unit also includes the energy, water, and fuel consumed on the building site during construction. If operational energy is included in the assessment, the reference unit includes the electrical and thermal energy consumed on site over the life of the building.

Data source

Tally utilizes a custom designed LCA database that combines material attributes, assembly details, and architectural specifications with environmental impact data resulting from the collaboration between KieranTimberlake and thinkstep. LCA modeling was conducted in GaBi 8.5 using GaBi 2018 databases and in accordance with GaBi databases and modeling principles.

The data used are intended to represent the US and the year 2017. Where representative data were unavailable, proxy data were used. The datasets used, their geographic region, and year of reference are listed for each entry. An effort was made to choose proxy datasets that are technologically consistent with the relevant entry.

Data quality and uncertainty

Uncertainty in results can stem from both the data used and their application. Data quality is judged by: its measured, calculated, or estimated precision; its completeness, such as unreported emissions; its consistency, or degree of uniformity of the methodology applied on a study serving as a data source; and geographical, temporal, and technological representativeness. The GaBi LCI databases have been used in LCA models worldwide in both industrial and scientific applications. These LCI databases have additionally been used both as internal and critically reviewed and published studies. Uncertainty introduced by the use of proxy data is reduced by using technologically, geographically, and/or temporally similar data. It is the responsibility of the modeler to appropriately apply the predefined material entries to the building under study.

System boundaries and delimitations

The analysis accounts for the full cradle to grave life cycle of the design options studied across all life cycle stages, including material manufacturing, maintenance and replacement, and eventual end of life. Optionally, the construction impacts and operational energy of the building can be included within the scope. Product stage impacts are excluded for materials and components indicated as existing or salvaged by the modeler. The modeler defines whether the boundary includes or excludes the flow of biogenic carbon, which is the carbon absorbed and generated by biological sources (e.g. trees, algae) rather than from fossil resources.

Architectural materials and assemblies include all materials required for the product's manufacturing and use including hardware, sealants, adhesives, coatings, and finishing. The materials are included up to a 1% cut-off factor by mass except for known materials that have high environmental impacts at low levels. In these cases, a 1% cut-off was implemented by impact.

Calculation Methodology

LIFE CYCLE STAGES

The following describes the scope and system boudaries used to define each stage of the life cycle of a building or building product, from raw material acquisition to final disposal. For products listed in Tally as Environmental Product Declarations (EPD), the full life cycle impacts are included, even if the published EPD only includes the Product stage [A1-A3].

Product [EN 15978 A1 - A3]

This encompasses the full manufacturing stage, including raw material extraction and processing, intermediate transportation, and final manufacturing and assembly. The product stage scope is listed for each entry, detailing any specific inclusions or exclusions that fall outside of the cradle to gate scope. Infrastructure (buildings and machinery) required for the manufacturing and assembly of building materials are not included and are considered outside the scope of assessment.

Transportation [EN 15978 A4]

This counts transportation from the manufacturer to the building site during the construction stage and can be modified by the modeler.

Construction Installation [EN 15978 A5] (Optional)

This includes the anticipated or measured energy and water consumed on-site during the construction installation process, as specified by the modeler.

Maintenance and Replacement [EN 15978 B2-B5]

This encompasses the replacement of materials in accordance with their expected service life. This includes the end of life treatment of the existing products as well as the cradle to gate manufacturing and transportation to site of the replacement products. The service life is specified separately for each product. Refurbishment of materials marked as existing or salvaged by the modeler is also included.

Operational Energy [EN 15978 B6] (Optional)

This is based on the anticipated or measured energy and natural gas consumed at the building site over the lifetime of the building, as indicated by the modeler.

End of Life [EN 15978 C2-C4]

This includes the relevant material collection rates for recycling, processing requirements for recycled materials, incineration rates, and landfilling rates. The impacts associated with landfilling are based on average material properties, such as plastic waste, biodegradable waste, or inert material. Stage C2 encompasses the transport from the construction site to end-of-life treatment based on national averages. Stages C3-C4 account for waste processing and disposal, i.e., impacts associated with landfilling or incineration.

Module D [EN 15978 D]

This accounts for reuse potentials that fall beyond the system boundary, such as energy recovery and recycling of materials. Along with processing requirements, the recycling of materials is modeled using an avoided burden approach, where the burden of primary material production is allocated to the subsequent life cycle based on the quantity of recovered secondary material. Incineration of materials includes credit for average US energy recovery rates.

PRODUCT	CONSTRUCTION	USE	END-OF-LIFE	MODULE D
A1. Extraction	**A4. Transport (to site)**	B1. Use	C1. Demolition	**D. Benefits and loads beyond the system boundary from:**
A2. Transport (to factory)	***A5. Construction Installation***	**B2. Maintenance**	**C2. Transport (to disposal)**	**1. Reuse**
A3. Manufacturing		**B3. Repair**	**C3. Waste processing**	**2. Recycling**
		B4. Replacement	**C4. Disposal**	**3. Energy recovery**
		B5. Refurbishment		
		B6. Operational energy		
		B7. Operational water		

Life-Cycle Stages as defined by EN 15978. Processes included in Tally modeling scope are shown in bold. Italics indicate optional processes.

Calculation Methodology

ENVIRONMENTAL IMPACT CATEGORIES

A characterization scheme translates all emissions and fuel use associated with the reference flow into quantities of categorized environmental impact. As the degree that the emissions will result in environmental harm depends on regional ecosystem conditions and the location in which they occur, the results are reported as impact potential. Potential impacts are reported in kilograms of equivalent relative contribution (eq) of an emission commonly associated with that form of environmental impact (e.g. kg CO_2eq).

The following list provides a description of environmental impact categories reported according to the TRACI 2.1 characterization scheme, the environmental impact model developed by the US EPA to quantify environmental impact risk associated with emissions to the environment in the United States. TRACI is the standard environmental impact reporting format for LCA in North America. Impacts associated with land use change and fresh water depletion are not included in TRACI 2.1. For more information on TRACI 2.1, reference Bare 2010, EPA 2012, and Guinée 2001. For further description of measurement of environmental impacts in LCA, see Simonen 2014.

Acidification Potential (AP) kg SO_2eq

A measure of emissions that cause acidifying effects to the environment. The acidification potential is a measure of a molecule's capacity to increase the hydrogen ion (H^+) concentration in the presence of water, thus decreasing the pH value. Potential effects include fish mortality, forest decline, and the deterioration of building materials.

Eutrophication Potential (EP) kg Neq

A measure of the impacts of excessively high levels of macronutrients, the most important of which are nitrogen (N) and phosphorus (P). Nutrient enrichment may cause an undesirable shift in species composition and elevated biomass production in both aquatic and terrestrial ecosystems. In aquatic ecosystems, increased biomass production may lead to depressed oxygen levels caused by the additional consumption of oxygen in biomass decomposition.

Global Warming Potential (GWP) kg CO_2eq

A measure of greenhouse gas emissions, such as carbon dioxide and methane. These emissions are causing an increase in the absorption of radiation emitted by the earth, increasing the natural greenhouse effect. This may, in turn, have adverse impacts on ecosystem health, human health, and material welfare.

Ozone Depletion Potential (ODP) kg CFC-11eq

A measure of air emissions that contribute to the depletion of the stratospheric ozone layer. Depletion of the ozone leads to higher levels of UVB ultraviolet rays reaching the earth's surface with detrimental effects on humans and plants. As these impacts tend to be very small, ODP impacts can be difficult to calculate and are prone to a larger margin of error than the other impact categories.

Smog Formation Potential (SFP) kg O_3eq

A measure of ground level ozone, caused by various chemical reactions between nitrogen oxides (NO_x) and volatile organic compounds (VOCs) in sunlight. Human health effects can result in a variety of respiratory issues, including increasing symptoms of bronchitis, asthma, and emphysema. Permanent lung damage may result from prolonged exposure to ozone. Ecological impacts include damage to various ecosystems and crop damage.

Primary Energy Demand (PED) MJ (lower heating value)

A measure of the total amount of primary energy extracted from the earth. PED tracks energy resource use, not the environmental impacts associated with the resource use. PED is expressed in energy demand from non-renewable resources and from renewable resources. Efficiencies in energy conversion (e.g. power, heat, steam, etc.) are taken into account when calculating this result.

Non-Renewable Energy Demand MJ (lower heating value)

A measure of the energy extracted from non-renewable resources (e.g. petroleum, natural gas, etc.) contributing to the PED. Non-renewable resources are those that cannot be regenerated within a human time scale. Efficiencies in energy conversion (e.g. power, heat, steam, etc.) are taken into account when calculating this result.

Renewable Energy Demand MJ (lower heating value)

A measure of the energy extracted from renewable resources (e.g. hydropower, wind energy, solar power, etc.) contributing to the PED. Efficiencies in energy conversion (e.g. power, heat, steam, etc.) are taken into account when calculating this result.

LCI Data

END-OF-LIFE [C2-C4]

A Life Cycle Inventory(LCI) is a compilation and quantification of inputs and outputs for the reference unit.The following LCI provides a summary of all energy, construction, transportation, and material inputs present in the study. Materials are listed in alphabetical order along with a list of all Revit families and Tally entries in which they occur, along with any notes and system boundaries accompanying their database entries. Each entry lists the detailed scope for the LCI data sources used from the GaBi LCI database and identifies the LCI data source.

For LCI data sourced from an Environmental Product Declaration (EPD), the product manufacturer, EPD identification number, and Program Operator are listed. Where the LCI source does not provide data for all life cycle stages, default North American average values are used. This is of particular importance for European EPD sources, as EPD data are generally only provided for the product stage, and North American average values are used for the remaining life cycle stages.

Where specific quantities are associated with a data entry, such as user inputs, energy values, or material mass, the quantity is listed on the same line as the title of the entry.

TRANSPORTATION [A4]

Default transportation values are based on the three-digit material commodity code in the 2012 Commodity Flow Survey by the US Department of Transportation Bureau of Transportation Statistics and the US Department of Commerce where more specific industry-level transportation is not available.

Transportation by Barge

Scope:
The data set represents the transportation of 1 kg of material from the manufacturer location to the building site by barge.

LCI Source:
GLO: Average ship, 1500t payload capacity/ canal ts (2017)
US: Diesel mix at filling station ts (2014)

Transportation by Container Ship

Scope:
The data set represents the transportation of 1 kg of material from the manufacturer location to the building site by container ship.

LCI Source:
GLO: Container ship, 27500 dwt payload capacity, ocean going ts (2017)
US: Heavy fuel oil at refinery (0.3wt.% S) ts (2014)

Transportation by Rail

Scope:
The data set represents the transportation of 1 kg of material from the manufacturer location to the building site by cargo rail.

LCI Source:
GLO: Rail transport cargo - Diesel, average train, gross tonne weight 1000t / 726t payload capacity ts (2017)
US: Diesel mix at filling station ts (2014)

Transportation by Truck

Scope:
The data set represents the transportation of 1 kg of material from the manufacturer location to the building site by diesel truck.

LCI Source:
US: Truck - Trailer, basic enclosed / 45,000 lb payload - 8b ts (2017)
US: Diesel mix at filling station ts (2014)

LCI Data (continued)

END-OF-LIFE [C2-C4]

Specific end-of-life scenarios are detailed for each entry based on the US construction and demolition waste treatment methods and rates in the 2016 WARM Model by the US Environmental Protection Agency except where otherwise specified. Heterogeneous assemblies are modeled using the appropriate methodologies for the component materials.

End-of-Life Landfill

Scope:

Materials for which no recycling or incineration rates are known, no recycling occurs within the US at a commercial scale, or which are unable to be recycled are landfilled. This includes glass, drywall, insulation, and plastics. The solids contents of coatings, sealants, and paints are assumed to go to landfill, while the solvents or water evaporate during installation. Where the landfill contains biodegradable material, the energy recovered from landfill gas utilization is reflected as a credit in Module D.

LCI Source:

US: Glass/inert on landfill ts (2017)
US: Biodegradable waste on landfill, post-consumer ts (2017)
US: Plastic waste on landfill, post-consumer ts (2017)

Concrete End-of-Life

Scope:

Concrete (or other masonry products) are recycled into aggregate or general fill material or they are landfilled. It is assumed that 55% of the concrete is recycled. Module D accounts for both the credit associated with off-setting the production aggregate and the burden of the grinding energy required for processing.

LCI Source:

US: Diesel mix at refinery ts (2014)
GLO: Fork lifter (diesel consumption) ts (2016)
EU - 28 Gravel 2/32 ts (2017)
US: Glass/inert on landfill ts (2017)

Metals End-of-Life

Scope:

Metal products are modeled using the avoided burden approach. The recycling rate at end of life is used to determine how much secondary metal can be recovered after having subtracted any scrap input into manufacturing (net scrap). Net scrap results in an environmental credit in Module D for the corresponding share of the primary burden that can be allocated to the subsequent product system using secondary material as an input. If the value in Module D reflects an environmental burden, then the original product (A1-A3) contains more secondary material than is recovered.

LCI Source:

Aluminum - RNA: Primary Aluminum Ingot AA/ts (2010)
Aluminum - RNA: Secondary Aluminum Ingot AA/ts (2010)
Brass - GLO: Zinc mix ts (2012)
Brass - GLO: Copper (99.99% cathode) ICA (2013)
Brass - EU-28: Brass (CuZn20) ts (2017)
Copper - DE: Recycling potential copper sheet ts (2016)
Steel - GLO: Value of scrap worldsteel (2014)
Zinc - GLO: Special high grade zinc IZA (2012)

Wood End-of-Life

Scope:

End of Life waste treatment methods and rates for wood are based on the 2014 Municipal Solid Waste and Construction Demolition Wood Waste Generation and Recovery in the United States report by Dovetail Partners, Inc. It is assumed that 63.5% of wood is sent to landfill, 22% to incineration, and 14.5% to recovery.

LCI Source:

US: Untreated wood in waste incineration plant ts (2017)
US: Wood product (OSB, particle board) waste in waste incineration plant ts (2017)
US: Wood products (OSB, particle board) on landfill, post-consumer ts (2017)
US: Untreated wood on landfill, post-consumer ts (2017)
RNA: Softwood lumber CORRIM (2011)

LCI Data

MODEL ELEMENTS

Revit Categories
- Ceilings
- Curtainwall Mullions
- Curtainwall Panels
- Doors
- Floors
- Roofs
- Stairs and Railings
- Structure
- Walls
- Windows

M3.1 Revit Model.rvt
- Worksets
  - Enclosure
  - Shared Levels and Grids
  - Structure
  - Workset1
- Phases
  - Existing
  - New Construction

PRODUCT [A1-A3]

Materials and components are listed in alphabetical order along with a list of all Revit families and Tally entries in which they occur. The masses given here refer to the quantity of each material used over the building's life-cycle, which includes both Product [A1-A3] and Use [B2-B5] stages.

Additional provided data describing scope boundaries for each life cycle stage may be useful for interpretation of the impacts associated with the specific material or component. Each material or component is listed with its service life, or period of time after installation it is expected to meet the service requirements prior to replacement or repair. This value is indicated in parentheses next to the mass of the material associated with the listed Revit family. Values for transportation distance or service life shown with an asterisk (*) indicate user-defined changes to default values. Values for service life shown with a dagger (†) indicate materials identified by the modeler as existing or salvaged.

Adhesive, polychloroprene (neoprene) **367.4 kg**

Used in the following Revit families:
- CLT Roof — 367.4 kg (20 yrs)

Used in the following Tally entries:
- EPDM, roofing membrane

Description:
Generic polychlorprene contact adhesive.

Life Cycle Inventory:
- Polychloroprene
- Alkylphenolic resin
- Magnesium oxide, tin oxide
- Solvents (petroleum ether/cycloaliphatic/ketone/ester blends)

Product Scope:
Cradle to gate, plus emissions during application, excludes energy for application

Transportation Distance:
By truck: 840 km

End-of-Life Scope:
27% solids to landfill (plastic waste)

LCI Source:
EU-28: Solvent-based polychloroprene adhesive of good heat resistance (estimation) (2017)

Aluminum, sheet **2,947.8 kg**

Used in the following Revit families:
- Generic - 5" — 2,947.8 kg (60 yrs)

Used in the following Tally entries:
- Insulated metal wall panel, custom

Description:
Aluminum sheet, formed and cut. Data based on industry-wide EPD for cold-rolled aluminum from the Aluminum Association (EPD ID 4786092064.101.1).

Life Cycle Inventory:
100% Aluminum

Product Scope:
Cradle to gate

Transportation Distance:
By truck: 663 km

End-of-Life Scope:
- 95% Recovered
- 5% Landfilled (inert material)

Module D Scope:
Product has 65% scrap input while remainder is processed and credited as avoided burden

LCI Source:
RNA: Cold Rolled Aluminium ts/AA (2010) [EPD]

LCI Data (continued)

GLO: Steel sheet stamping and bending (5% loss) ts (2017)
US: Electricity grid mix ts (2014)
US: Lubricants at refinery ts (2014)
GLO: Compressed air 7 bar (medium power consumption) ts (2014)
RNA: Primary Aluminum Ingot AA/ts (2010)
RNA: Secondary Aluminum Ingot AA/ts (2010)

Cellulose insulation, boards **15,245.2 kg**

Used in the following Revit families:
Generic - 5" 15,245.2 kg (60 yrs)

Used in the following Tally entries:
Steel, C-stud metal framing with insulation

Description:
Cellulose insulation, boards

Life Cycle Inventory:
Waste paper fibers
Tall oil resin
Ferrochrome-lignine sulfonate
Borax

Product Scope:
Cradle to gate

Transportation Distance:
By truck: 1020 km

End-of-Life Scope:
100% Landfilled (biodegradable waste)

LCI Source:
DE: Cellulose fibre boards (EN 15804 A1-A3) ts (2017)

CLT (Cross laminated timber) **536,582.1 kg**

Used in the following Revit families:
CLT 429,265.7 kg (60 yrs)
CLT Roof 107,316.4 kg (60 yrs)

Used in the following Tally entries:
Cross laminated timber (CLT)

Description:
Engineered wood panel made of several layers of kiln-dried lumber stacked in alternating directions, bonded with structural adhesives, and pressed to form a solid rectangular panel.

Life Cycle Inventory:
Proxied by Glulam

Product Scope:
Cradle to gate

Transportation Distance:
By truck: 468 km

End-of-Life Scope:
14.5% Recovered
22% Incinerated with energy recovery
63.5% Landfilled (wood product waste)

Module D Scope:
Recovered wood products credited as avoided burden.

LCI Source:
RNA: Glue laminated timbers CORRIM (2011)

Cold formed structural steel **7,135.3 kg**

Used in the following Revit families:
Generic - 5" 7,135.3 kg (60 yrs)

Used in the following Tally entries:
Steel, C-stud metal framing with insulation

Description:
Cold-rolled or formed structural steel, such as used in steel studs.

Life Cycle Inventory:
100% Cold rolled steel

Product Scope:
Cradle to gate

Transportation Distance:
By truck: 431 km

End-of-Life Scope:
98% Recovered
2% Landfilled (inert material)

Module D Scope:
Product has 16% scrap input while remainder is processed and credited as avoided burden

LCI Source:
RNA: Steel finished cold rolled coil worldsteel (2007)
GLO: Steel sheet stamping and bending (5% loss) ts (2017)
US: Electricity grid mix ts (2014)
US: Lubricants at refinery ts (2014)
GLO: Compressed air 7 bar (medium power consumption) ts (2014)
GLO: Value of scrap worldsteel (2014)

Curtain wall system, Kawneer, 1600 Wall System - EPD **33,355.7 kg**

Used in the following Revit families:
System Panel 33,355.7 kg (60 yrs)

Used in the following Tally entries:
Curtainwall System (including glazing)

Description:
Thermally broken aluminum curtain wall system by Kawneer INCLUSIVE of glazing units, appropriate for low-to-mid-rise applications, including the 1600, 1620, 1630, 2250, and 7500 curtainwall system lines. Includes mullions, glazing, and all necessary gaskets and sealants. The reference window unit size is 1.5m x 1.6m. EPD representative of conditions in North America.

Life Cycle Inventory:
For information and quantities, see EPD

Product Scope:
Cradle to gate

Transportation Distance:
By truck: 663 km

End-of-Life Scope:
95% recovery rate
5% landfill (inert)

Module D Scope:
Credit given for the avoided burden associated with recovered material

LCI Source:
EPD (US), Kawneer North America (2015)

EPD Source:
47868332121.105.1

EPD Designation Holder:
Kawneer North America

EPD Program Operator:
UL Environment

EPD Expiration:
11/16/2020

EPDM, non-reinforced membrane, 60 mils, SPRI - EPD **7,788.5 kg**

Used in the following Revit families:
CLT Roof 7,788.5 kg (20 yrs)

Used in the following Tally entries:
EPDM, roofing membrane

Description:
Non-reinforced ethylene propylene diene terpolymer (EPDM) synthetic rubber roofing membrane, default thickness of 60 mils (1.5 mm). Industry-wide EPD from the Single Ply Roofing Industry.

Life Cycle Inventory:
For information and quantities, see EPD

Product Scope:
Cradle to gate

Transportation Distance:
By truck: 172 km

LCI Data (continued)

End-of-Life Scope:
100% Landfilled (plastic waste)

LCI Source:
US: Non-reinforced EPDM single ply roofing membrane, 60 mils, A1-A3 - SPRI ts (2017)

EPD Source:
4786842353.103.1

EPD Designation Holder:
Single Ply Roofing Industry (SPRI)

EPD Program Operator:
UL Environment

EPD Expiration:
2/14/2022

Expanded polystyrene (EPS), board **2,293.7 kg**

Used in the following Revit families:
SOG Floor Insulation 2,293.7 kg (60 yrs)

Used in the following Tally entries:
Expanded polystyrene (EPS), board

Description:
EPS foam insulation board

Life Cycle Inventory:
100% Expanded polystyrene board

Product Scope:
Cradle to gate

Transportation Distance:
By truck: 1299 km

End-of-Life Scope:
100% Landfilled (plastic waste)

LCI Source:
US: EPS-Foam (expanded polystyrene foam (PS 12)) incl. flame retardant (estimation) ts (2017)

Fasteners, stainless steel **1,650.6 kg**

Used in the following Revit families:
Generic - 5" 1,650.6 kg (60 yrs)

Used in the following Tally entries:
Insulated metal wall panel, custom

Description:
Stainless steel part, appropriate for use as fasteners and specialized hardware (bolts, rails, clips, etc.). Data based on industry-wide EPDs for primary and secondary metal from the World Steel Association.

Life Cycle Inventory:
100% Stainless steel

Product Scope:
Cradle to gate

Transportation Distance:
By truck: 1001 km

End-of-Life Scope:
98% Recovered
2% Landfilled (inert material)

Module D Scope:
Product has 58% scrap input while remainder is processed and credited as avoided burden

LCI Source:
RER: Stainless steel Quarto plate (304) Eurofer (2010)
GLO: Steel turning ts (2017)
US: Electricity grid mix ts (2014)
RER: Stainless steel flat product (304) - value of scrap Eurofer (2010)

Fiberglass mat gypsum sheathing board **18,381.2 kg**

Used in the following Revit families:
Generic - 5" 18,381.2 kg (60 yrs)

Used in the following Tally entries:
Fiberglass mat gypsum sheathing

Description:
Fiberglass treated gypsum sheathing product appropriate for use in high-moisture environments.

Life Cycle Inventory:
92% Gypsum
8% Fiberglass mat

Product Scope:
Cradle to gate

Transportation Distance:
By truck: 172 km

End-of-Life Scope:
100% Landfilled (inert waste)

LCI Source:
DE: Gypsum plaster board (Moisture resistant) (EN15804 A1-A3) ts (2017)
US: Fiberglass Duct Board NAIMA (2007)

Glue laminated timber (Glulam), AWC - EPD **418,714.1 kg**

Used in the following Revit families:
Glulam-Southern Pine 377,088.3 kg (60 yrs)
Glulam-Western Species-Column 41,625.8 kg (60 yrs)

Used in the following Tally entries:
Glue laminated timber (Glulam)

Description:
Architectural grade structural glue-laminated timber (Glulam), an engineered wood product manufactured from end-joined, laminated, and planed lumber pressure-treated with resins. Typically used for beams, headers, columns, and arches. Entry inclusive of factory applied sealer. Industry-wide EPD from the American Wood Council.

Life Cycle Inventory:
For information and quantities, see EPD

Product Scope:
Cradle to gate

Transportation Distance:
By truck: 468 km

End-of-Life Scope:
14.5% Recovered
22% Incinerated with energy recovery
63.5% Landfilled (wood product waste)

Module D Scope:
Recovered wood products credited as avoided burden.

LCI Source:
RNA: Glue laminated timbers CORRIM (2011)

EPD Source:
13CA24184.104.1

EPD Designation Holder:
American Wood Council and Canadian Wood Council

EPD Program Operator:
UL Environment

EPD Expiration:
4/16/2019

Lightweight concrete, 3000 psi, 20% fly ash **956,016.1 kg**

Used in the following Revit families:
CLT 764,812.9 kg (60 yrs)
CLT Roof 191,203.2 kg (60 yrs)

Used in the following Tally entries:
Cast-in-place concrete, lightweight structural concrete, 3000 psi

Description:
Lightweight concrete, 3000 psi, 20% fly ash. Mix design matches National Ready-Mix Concrete Association (NRMCA) Industry-wide EPD.

LCI Data (continued)

Life Cycle Inventory:
Sand: 45%, Expanded shale: 29%, Portland cement PCA - EPD: 13%, Water: 9%, Fly ash: 3%, Admixture: <1%

Product Scope:
Cradle to gate
Anchors, ties, and metal accessories outside of scope (<1% mass)

Transportation Distance:
By truck: 24 km

End-of-Life Scope:
55% Recycled into coarse aggregate
45% Landfilled (inert material)

Module D Scope:
Avoided burden credit for coarse aggregate, includes grinding energy

LCI Source:
US: Portland cement PCA/ts (2014)
DE: Pumice gravel (grain size 4/16) (EN15804 A1-A3) ts (2017)
DE: Gravel (Grain size 2/32) (EN15804 A1-A3) s (2017)
DE: Fly ash (EN15804 A1-A3) ts (2017)
DE: Slag-tap granulate (EN15804 A1-A3) ts (2017)
DE: Expanded clay (EN15804 A1-A3) ts (2017)
DE: alcium nitrate ts (2017)
DE: Sodium ligninsulfonate ts (2017)
DE: Sodium naphtalene sulfonate [estimated] ts (2017)
US: Sodium hydroxide (caustic soda) ix (100%) ts (2017)
US: Colophony (rosin, refined) from CN pine gum rosin ts (2017)
US: Tap water from groundwater ts (2017)
US: Electricity grid mix s (2014)
US: Natural gas mix ts (2014)
US: Diesel mix at filling station (100% fossil) ts (2014)
US: Liquefied Petroleum Gas (LPG) (70% propane
30% utane) ts (2014)
US: Light fuel oil at refinery ts (2014)

Paint, interior acrylic latex **3,296.8 kg**

Used in the following Revit families:
Generic - 5" 3,296.8 kg (7 yrs)

Used in the following Tally entries:
Wall board, gypsum

Description:
Acrylic-based paint for interior applications

Life Cycle Inventory:
21% Binding agent
35% Pigments and fillers
42% Water
2% Organic solvents

Product Scope:
Cradle to gate, including emissions during application

Transportation Distance:
By truck: 642 km

End-of-Life Scope:
100% to landfill (plastic waste)

LCI Source:
DE: Application paint emulsion (building, interior, white, wear resistant) ts (2017)

PIR rigid foam insulation, roof, R=15, PIMA - EPD **6,096.1 kg**

Used in the following Revit families:
CLT Roof 6,096.1 kg (60 yrs)

Used in the following Tally entries:
Polyisocyanurate (PIR), board

Description:
Polyisocyanurate rigid foam roof insulation with glass-fiber reinforced facers, R-value of 15, 2.6" thickness (66 mm). Industry-wide EPD from the Polyisocyanurate Insulation Manufacturers Association.

Life Cycle Inventory:
For information and quantities, see EPD

Product Scope:
Cradle to gate

Transportation Distance:
By truck: 250 km

End-of-Life Scope:
100% Landfilled (plastic waste)

LCI Source:
RNA: Polyisocyanurate rigid foam board roof insulation, R=15 (A1-A3) ts-EPD (2013)

EPD Source:
EPD10043

EPD Designation Holder:
Polyisocyanurate Insulation Manufacturers Association

EPD Program Operator:
NSF International

EPD Expiration:
2/6/2020

Polyurethane foam (PUR) rigid board **2,286.8 kg**

Used in the following Revit families:
Generic - 5" 2,286.8 kg (60 yrs)

Used in the following Tally entries:
Insulated metal wall panel, custom

Description:
Polyurethane foam insulation board

Life Cycle Inventory:
100% Polyurethane rigid foam (PUR) (butane blowing agent)

Product Scope:
Cradle to gate

Transportation Distance:
By truck: 1299 km

End-of-Life Scope:
100% Landfilled (plastic waste)

LCI Source:
DE: Polyurethane rigid foam (PUR) (EN15804 A1-A3) ts (2017)

Powder coating, metal stock **1,463.0 kg**

Used in the following Revit families:
Generic - 5" 1,463.0 kg (50 yrs)

Used in the following Tally entries:
Insulated metal wall panel, custom

Description:
Powder coating, for metal stock

Life Cycle Inventory:
100% Powder coating

Product Scope:
Cradle to gate, including application

Transportation Distance:
N/A

End-of-Life Scope:
100% Landfilled (inert waste)

LCI Source:
DE: Application top coat powder (aluminium) ts (2017)
DE: Coating powder (industry, outside, red) ts (2017)

Steel, reinforcing rod **104,337.9 kg**

Used in the following Revit families:
CLT 12,508.1 kg (60 yrs)
CLT Roof 3,127.0 kg (60 yrs)
Concrete - 16" 77,470.3 kg (60 yrs)
Footing-Rectangular 4,313.2 kg (60 yrs)
SOG Floor 6,919.2 kg (60 yrs)

Used in the following Tally entries:
Cast-in-place concrete, lightweight structural concrete, 3000 psi
Cast-in-place concrete, structural concrete, 4000 psi
Cast-in-place concrete, structural concrete, 6000 psi

LCI Data (continued)

Description:
Common unfinished tempered steel rod suitable for structural reinforcement (rebar)

Life Cycle Inventory:
100% Steel rebar

Product Scope:
Cradle to gate

Transportation Distance:
By truck: 431 km

End-of-Life Scope:
70% Recovered
30% Landfilled (inert material)

Module D Scope:
Product has a 16.4% scrap input while remainder is processed and credited as avoided burden.

LCI Source:
GLO: Steel rebar worldsteel (2014)

Steel, sheet **6,357.7 kg**

Used in the following Revit families:
Generic - 5" 6,357.7 kg (60 yrs)

Used in the following Tally entries:
Insulated metal wall panel, custom

Description:
Steel sheet

Life Cycle Inventory:
100% Steel sheet

Product Scope:
Cradle to gate

Transportation Distance:
By truck: 418 km

End-of-Life Scope:
98% Recovered
2% Landfilled (inert material)

Module D Scope:
Product has 16% scrap input while remainder is processed and credited as avoided burden

LCI Source:
RNA: Steel finished cold rolled coil worldsteel (2007)
GLO: Steel sheet stamping and bending (5% loss) ts (2017)
US: Electricity grid mix ts (2014)
US: Lubricants at refinery ts (2014)
GLO: Compressed air 7 bar (medium power consumption) ts (2014)
GLO: Value of scrap worldsteel (2014)

Structural concrete, 4000 psi, 20% fly ash **652,182.7 kg**

Used in the following Revit families:
Footing-Rectangular 298,930.1 kg (60 yrs)
SOG Floor 353,252.5 kg (60 yrs)

Used in the following Tally entries:
Cast-in-place concrete, structural concrete, 4000 psi

Description:
Structural concrete, 4000 psi, 20% fly ash. Mix design matches National Ready-Mix Concrete Association (NRMCA) Industry-wide EPD.

Life Cycle Inventory:
Coarse aggregate: 45%, Sand: 31%, Portland cement PCA - EPD: 14%, Water: 7%, Fly ash: 3%, Admixture: <1%

Product Scope:
Cradle to gate
Anchors, ties, and metal accessories outside of scope (<1% mass)

Transportation Distance:
By truck: 24 km

End-of-Life Scope:
55% Recycled into coarse aggregate
45% Landfilled (inert material)

Module D Scope:
Avoided burden credit for coarse aggregate, includes grinding energy

LCI Source:
US: Portland cement PCA/ts (2014)
DE: Pumice gravel (grain size 4/16) (EN15804 A1-A3) ts (2017)
DE: Gravel (Grain size 2/32) (EN15804 A1-A3) s (2017)
DE: Fly ash (EN15804 A1-A3) ts (2017)
DE: Slag-tap granulate (EN15804 A1-A3) ts (2017)
DE: Expanded clay (EN15804 A1-A3) ts (2017)
DE: alcium nitrate ts (2017)
DE: Sodium ligninsulfonate ts (2017)
DE: Sodium naphtalene sulfonate [estimated] ts (2017)
US: Sodium hydroxide (caustic soda) ix (100%) ts (2017)
US: Colophony (rosin, refined) from CN pine gum rosin ts (2017)
US: Tap water from groundwater ts (2017)
US: Electricity grid mix s (2014)
US: Natural gas mix ts (2014)
US: Diesel mix at filling station (100% fossil) ts (2014)
US: Liquefied Petroleum Gas (LPG) (70% propane
30% utane) ts (2014)
US: Light fuel oil at refinery ts (2014)

Structural concrete, 6000 psi, Pacific Southwest regional average **653,458.2 kg**

Used in the following Revit families:
Concrete - 16" 653,458.2 kg (60 yrs)

Used in the following Tally entries:
Cast-in-place concrete, structural concrete, 6000 psi

Description:
Structural concrete, 6000 psi, Pacific Southwest regional average. Mix design matches National Ready-Mix Concrete Association (NRMCA) Industry-wide EPD.

Life Cycle Inventory:
Coarse aggregate: 36%, Sand: 36%, Portland cement PCA - EPD: 16%, Water: 9%, Fly ash: 2%, Admixture: <1%

Product Scope:
Cradle to gate
Anchors, ties, and metal accessories outside of scope (<1% mass)

Transportation Distance:
By truck: 24 km

End-of-Life Scope:
55% Recycled into coarse aggregate
45% Landfilled (inert material)

Module D Scope:
Avoided burden credit for coarse aggregate, includes grinding energy

LCI Source:
US: Portland cement PCA/ts (2014)
DE: Pumice gravel (grain size 4/16) (EN15804 A1-A3) ts (2017)
DE: Gravel (Grain size 2/32) (EN15804 A1-A3) s (2017)
DE: Fly ash (EN15804 A1-A3) ts (2017)
DE: Slag-tap granulate (EN15804 A1-A3) ts (2017)
DE: Expanded clay (EN15804 A1-A3) ts (2017)
DE: alcium nitrate ts (2017)
DE: Sodium ligninsulfonate ts (2017)
DE: Sodium naphtalene sulfonate [estimated] ts (2017)
US: Sodium hydroxide (caustic soda) ix (100%) ts (2017)
US: Colophony (rosin, refined) from CN pine gum rosin ts (2017)
US: Tap water from groundwater ts (2017)
US: Electricity grid mix s (2014)
US: Natural gas mix ts (2014)
US: Diesel mix at filling station (100% fossil) ts (2014)
US: Liquefied Petroleum Gas (LPG) (70% propane
30% utane) ts (2014)
US: Light fuel oil at refinery ts (2014)

Wall board, gypsum, natural **38,112.9 kg**

Used in the following Revit families:
Generic - 5" 38,112.9 kg (30 yrs)

Used in the following Tally entries:
Wall board, gypsum

Description:
Natural gypsum board

LCI Data (continued)

Life Cycle Inventory:
100% Gypsum wallboard (Gypsum, Boric acid, Cement, Glass fibres, Ferrochrome-lignine sulfonate, Silane, Polyglucose, Perlite, Paper, Casein glue)

Product Scope:
Cradle to gate

Transportation Distance:
By truck: 172 km

End-of-Life Scope:
100% Landfilled (inert waste)

LCI Source:
DE: Gypsum wallboard (EN15804 A1-A3) ts (2017)