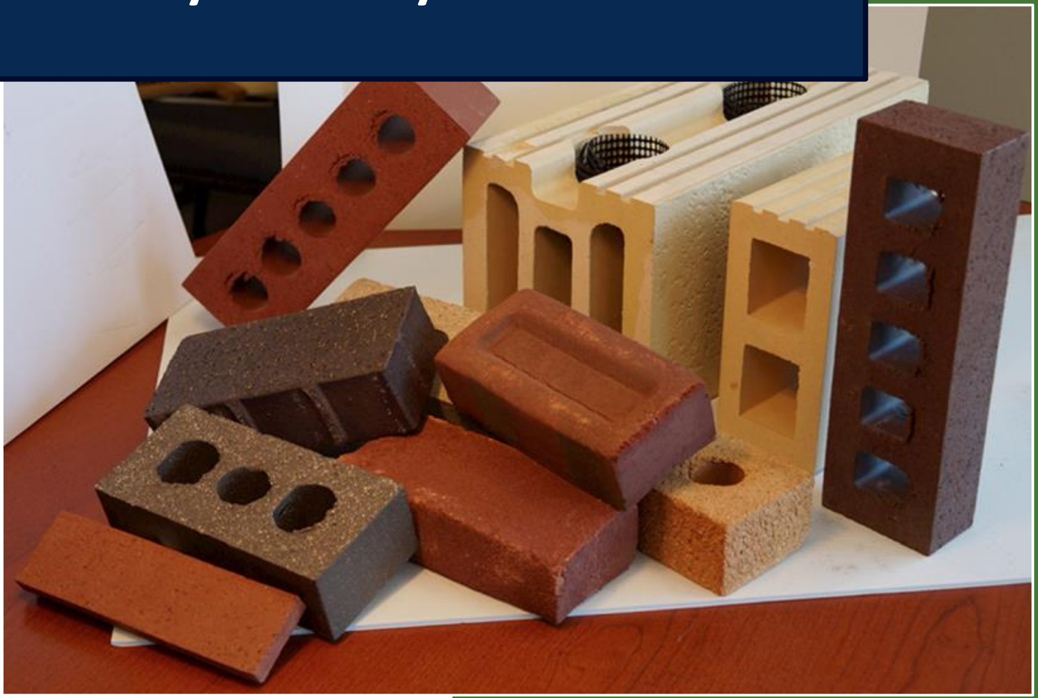
SustainableSolutions CORPORATION

Brick Industry Association EPD Tool Background Report – Pacific Clay and Clay Masonry Products



Prepared For:

Pacific Clay

February 2026

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EPD Tool Background Report

Pacific Clay Products Inc.

Clay Brick & Structural Clay Tiles, Clay Brick Pavers, and Thin Brick

2/25/2026

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EPD Tool Commissioned by Brick Industry Association (BIA)

Background LCA Commissioned by Pacific Clay Products Inc.

LCA Practitioner: Sustainable Solutions Corporation

Prepared for:

Pacific Clay Products Inc.

14741 Lake Street

Lake Elsinore, California 92530, Riverside USA

Conducted according to ISO 14040, 14044, and 21930:2017 International Standards and in alignment with NSF International / ASTM International Product Category Rules for Preparing an EPD for Clay Brick, Clay Brick Pavers, and Structural Clay Tile, version 1.0, valid through September 30, 2030.

LCA Tool Background Report Summary

PRODUCT TYPES INCLUDED	Clay brick structural clay tiles Clay brick pavers Thin bricks
FUNCTIONAL UNIT	1 m^2 of installed brick
LCA SCOPE	Cradle-to-Grave
PROGRAM OPERATOR	NSF International 789 N. Dixboro Road, Ann Arbor, MI 48105, USA
PROGRAM CATEGORY RULES	NSF PCR: Product Category Rules for Preparing an EPD for Clay Brick, Clay Brick Pavers, and Structural Clay Tile
REFERENCE STANDARDS	ISO 14040/14044 ISO 14025 ISO 21930:2017
MANUFACTURER	Pacific Clay Products Inc. 14741 Lake Street Lake Elsinore, California, 92530
LCA STUDY DETAILS	Completed: [DATE] LCA Practitioner: Sustainable Solutions Corporation (SSC)
LCA REVIEW DETAILS	Completed: [DATE] LCA Reviewer: Jack Geibig, Ecoform ☐ INTERNAL ☒ EXTERNAL
YEAR OF PRIMARY DATA	2023
LCA SOFTWARE	SimaPro v.9.6
LCA DATABASE	USLCI, ecoinvent 3.11
LCIA METHODOLOGY	TRACI 2.2
APPLICABLE REGION	North America
CRADLE-TO-GRAVE GWP (TRACI 2.2) STRUCTURAL CLAY BRICK (kg CO2 per m^2)	58.06
CRADLE-TO-GRAVE GWP (TRACI 2.2) CLAY BRICK PAVER (kg CO2 per m^2)	74.44
CRADLE-TO-GRAVE GWP (TRACI 2.2) THIN BRICK (kg CO2 per m^2)	50.57

Table of Contents

List of Figures

List of Tables

1.0 Goal and Scope

Life cycle assessment (LCA) is a powerful tool used to quantify the environmental impacts associated with the various stages of a product's life. Section 1 provides a background and overview of LCA methodology, the goal and scope of this study, and the system boundary.

1.1 Goal of the Study

The goal of this analysis is to identify and quantify the environmental impacts associated with each stage in the life cycle of the clay brick, clay brick pavers, and structural clay tiles products, including raw material extraction, processing, and shipping; manufacturing; final product shipping; product installation and use; and end-of-life disposition.

The Brick Industry Association (BIA) partnered with the NSF International to develop an updated PCR for Clay Brick, Clay Brick Pavers, and Structural Clay Tiles. Pacific Clay has commissioned SSC to create this report, which is compliant to the NSF Brick PCR, as well as LCA standards ISO 14040/14044 and ISO 21930.

Intended Uses

LCA is a tool that can effectively be applied for manufacturing process improvements, education and market support, environmental management, and sustainable reporting. Pacific Clay, which is the primary audience of the study, intends to use the study results mainly for the following purposes:

- To publish an EPD as demanded by the market for marketing or competitive purposes.
- To evaluate the impacts of the clay brick, clay brick pavers, and structural clay tiles across the product life cycle.
- To integrate sustainable product design techniques to reduce impacts, to the extent possible.
- To evaluate possible process improvements in the manufacture of clay brick, clay brick pavers, and structural clay tiles.

1.2 Scope of the Study

This LCA study is characterized as a "cradle-to-grave" study, examining the clay brick, clay brick pavers, and structural clay tiles from raw material extraction through final disposal. This study is also classified as "Business-to-Consumer" where the information may be used for final customers to make decisions based on the potential environmental impacts calculated from this scope. The nature of the life cycle assessment is to include a wide range of inputs associated with the product being analyzed. Constraining the LCA scope is an essential part of the study. Brick products come in a variety of dimensions and configurations. Scaling factors are implemented to calculate dimension-specific product impacts based on a reference product's impacts. As such, the reference products and manufacturing coverage of the products that are included in the scope of this study are listed in the table below.

Table 1.1 – Products within Study Scope

	Clay Brick & Structural Clay Tile	Clay Brick Paver	Thin Brick
Reference Product	Modular	STD Full	Mod Thin Bri
Technical Standards	C216, C652	C902	C1088
Dimensions (W x H x L)	3.625 x 2.25 x 7.625	3.78 x 2.25 x 8	0.625 x 2.25 x 7.625
Void Space	16%	0%	0%
Manufacturing Coverage	Lake Elsinore, California		

Due to the scope of this study, the resultant EPD will be classified as product-specific, facility-specific.

1.3 Functional Unit

All flows to and from the environment within the system boundary (see Section 1.6 below) are normalized to a unit summarizing the function of the system. Clay brick assemblies fulfill multiple functions in wall and paving applications. Capable of serving as a cladding, structural wall or solid base for pedestrian and vehicular traffic, clay brick assemblies provide strength, moisture resistance, thermal performance, fire resistance, and acoustic benefits, while allowing unique architectural forms. Once the primary functions of the systems are defined, a functional unit is selected to provide a similar basis for summarizing the LCA which is consistent with the goals mentioned above. The functional unit utilized for this study is 1 square meter of installed product, including joints, with a service life of 150 years, including end-of-life disposition. Table 1.2 lists specific details of the functional unit for clay brick assemblies.

The values provided in the following table are for the baseline products for each sub-category of brick. This study evaluates many brick products of each type, which are defined and evaluated by the scaling factor tables found in Appendix C: EPD and Scaling Factor Tables.

Table 1.2 – Functional Unit Details

	Clay Brick & Structural Clay Tile	Clay Brick Paver	Thin Brick
Functional Unit	1 m^2 of vertically installed brick using 0.95 cm (3/8") mortar joints for the estimated life of the building	1 m^2 of horizontally installed brick paver using 3.2 mm (1/8") sand joints for the estimated life of the installed surface	1 m^2 of vertically installed brick using 0.95 cm (3/8") mortar joints for the estimated life of the building
Mass of Functional Unit (kg)	162.2	121.9	36.9
Number of Bricks per Functional Unit	75.0	48.9	73.8
Mass of Brick per Functional Unit (kg)	129.3	121.9	25.1
Mass of Mortar per Functional Unit (kg)	32.9	0.0	11.8
Brick Depth (cm)	9.2075	9.6012	1.5875
Brick Height (cm)	5.715	5.715	5.715
Brick Length (cm)	19.05	20.32	19.3675
Joint Size (cm)	0.95	0.32	0.95
Brick Density (kg/m^3)	1987.9	1987.9	1987.9
Void Space	16%	0%	0%
Reference Service Life (years)	150	150	150
Technical Standards	ASTM C216	ASTM C902	ASTM C1088

1.4 System Boundary

This project considers the life cycle activities from resource extraction through product end-of-life for a 150-year life cycle inclusive of installation, use, and maintenance effects. Figure 1.1 defines the system boundary for clay brick assemblies.

A1 - Raw Materials

- Production and extraction of raw materials

A2 - Raw Materials Transportation

- Diesel consumption

A3 - Manufacturing

- Energy (fuels, electricity, steam)
- Water
- Waste (hazardous, non-hazardous, and wastewater)
- Emissions (air, water)
- Packaging materials
- Support materials

A4 - Final Product Transportation / Distribution

- Diesel consumption

A5 - Installation

- Product scrap (including raw materials extraction and processing through final product distribution and disposal)
- Packaging disposal
- Installation materials (mortar, sand, and water)

B - Use

- Replacements (production of raw materials through installation, plus disposal x replacement frequency)
- Cleaning materials (soap, water, wastewater)
- Energy use
- Water use

C - Disposal

- Transportation to waste processing
- Landfill processing and emissions
- Incineration processing and emissions

D - Benefits and Loads Beyond the System Boundary

- Virgin raw material offset through product re-use

Figure 1.1 – System Boundary

Both human activity[1] and capital equipment[2] were excluded from the system boundary. The details of the data excluded from the system boundary can be found in the subsequent inventory sections.

Table 1.3 – System Boundary Exclusions

Data Excluded from System Boundary
• Construction of capital equipment • Human labor and employee commute • Maintenance of operation and support equipment • Overhead energy use (cafeterias, corporate offices, etc.) • Irrigation system for campus landscape • Sand for joints in clay brick paver installation • Energy for mixing mortar during installation of clay brick & structural clay tile and thin brick

1.5 Cut-off Criteria

Processes whose total contribution to the final result, with respect to their mass and in relation to all considered impact categories, is less than 1% can be neglected. The sum of the neglected processes may not exceed 5% by mass and by 5% of the considered impact categories. Documented assumptions are admissible.

For hazardous substances, as defined by the U.S. Occupational Health and Safety Act, the following requirements apply:

- The Life Cycle Inventory (LCI) of hazardous substances will be included if the inventory is available.
- If the LCI for a hazardous substance is not available, the substance will appear as an input in the LCI of the product if its mass represents more than 0.1% of the product composition.
- If the LCI of a hazardous substance is approximated by modeling another substance, documentation will be provided.

This LCA complies with the cut-off criteria since no known processes were neglected or excluded from this analysis outside of the specific items listed under "Excluded" in Table 1.3. No hazardous or toxic substances that pose a concern to human health and/or the environment are present in the products described in this report.

[1] Human activity involved in product manufacturing and component materials has a burden on the environment; however, the data collection required to properly quantify human involvement is particularly complicated. Allocating such flows to the production process, as opposed to other societal activities, was not feasible for a study of this nature.

[2] The environmental effects of manufacturing and installing capital equipment and buildings have generally been shown to be minor relative to the throughput of materials and components over the useful lives of the buildings and equipment.

1.6 Assumptions by Module

Many assumptions and approximations are necessary in the development of an LCI and LCA. This section will outline each of the important assumptions in this LCA.

- A1 Raw Materials
  - The average fuel consumption of mining clay and shale was assumed to be 0.2021 gallons per ton (0.765 liters per ton) as dictated by the PCR. As per the PCR, the only relevant inventory items for mining were the diesel consumed by machinery and the clay/shale material extracted from the Earth.
  - Body additives were assumed to be barium carbonate, modeled as Barium carbonate {GLO}| market for barium carbonate | Cut-off, U.
  - The density of clay brick assemblies was assumed to be 1,987.9 kg/m^3.
- A3 Manufacturing
  - Some primary data were not available for the facilities included in this study. Therefore, for any such required values, the BIA Industry Wide LCA study was used to provide an estimate value. The inventory items that were assumed by this method accounted for less than 5% of the total impact contribution for each impact category and were determined to have minimal impact on the overall results of the study.
  - A transportation distance of 32 kilometers (km) was assumed for all support materials, on-site fuels (excluding natural gas), packaging, and manufacturing waste disposal.
- A4 Distribution
  - The average transportation distance for clay brick assemblies, as specified in the PCR, was assumed in this study.
- A5 Installation
  - The average installation scrap for clay brick assemblies was assumed to be 5% by area, as per the PCR.
  - Waste disposal of both products and packaging was assumed to follow the most recent EPA waste statistics as outlined in Section 4.5.
  - Installation support materials fall outside of the control of Pacific Clay, as such the following assumptions were implemented:
    - The average composition of dry mortar mix was assumed to be in accordance with the PCR specifications. The composition was determined to be:
      - Portland Cement: 20%
      - Sand: 75%
      - Calcium Carbonate: 5%
- B Use
  - The building service life (ESL) was assumed to 75 years, in alignment with typical North American occurrences. The reference service life (RSL) was determined to be 150 years in alignment with the PCR.
- C End-of-Life
  - Waste disposal of the products was assumed to follow the most recent EPA waste statistics as outlined in Section 4.5.
  - The cut-off method is followed such that energy recovery is not included in End-of-life.

In addition, this study follows the modularity and polluter pays principle.

1.7 Allocation

Allocation of manufacturing inputs to each facility's brick products was conducted using the guidance of ISO 21930. Since the majority of energy is used in the firing of brick products, the inputs were allocated evenly over the fired brick weight production. Energy usage did not depend on brick specifications (such as pigment usage or shape) so the allocation over mass is not expected to introduce error.

Thin brick production required the use of allocation assumptions as the individual facilities did not have sub-metered data to facilitate accurate allocation of the energy, materials, and waste required for thin brick production. The facilities produced thin brick by:

- The "cutting" method; a 25% cored modular brick is produced, and then one ½" face is cut and the remainder is reincorporated into the process. The ratio of product weight per unit to fired weight per unit is 5.583, which is used to scale the allocation of manufacturing inputs to the product weight per unit.

2.0 Data Sources, Modeling Software, and Methodological Choices

The quality of results of an LCA study are directly dependent on the quality of input data used in the model. This section describes the data quality guidelines used in this study, the sources from which the data were selected, the software used to model the environmental impacts, and any data excluded from the scope of the study.

The NSF Clay Masonry Products PCR has clear data hierarchy instructions. Those instructions have been followed in this report, unless noted otherwise.

2.1 Primary Data

Primary data are the information collected directly from Pacific Clay. Primary data from the manufacturer were from the latest full calendar year of data available at the start of the project which was calendar year 2023. The range of data gathered span 12 months of time. This primary data are based on direct information sources of the manufacturer.

For primary data collected, plant personnel at Pacific Clay filled out a data collection template that included production data and energy and materials used on-site, all for the calendar year of 2023. This data was then evaluated while completing the life cycle inventory of the study.

- *Consistency*
    - Since the data were aggregated on an annual basis and the data were reported on a regular frequency, the consistency is considered high.
- *Completeness*
    - System boundaries and exclusions are clearly defined in the sections above, and no other data gaps were identified.
- *Precision*
    - The precision of this primary data was not quantified. However, the collected data are based on direct sources of information and were judged by the operations personnel to be accurate, so the precision is considered to be moderately high.
- *Reproducibility*

    - Confidential data from the plant(s) would inhibit reproducing these results without access to the data. However, tracking systems in place by Pacific Clay allows for the data to be accessible to reproduce this study for the calendar year in the scope.
- *Representativeness*
    - The data collected represent 100% of Pacific Clay production of clay brick assemblies and are representative of the products as documented in Section 2.2.
- *Uncertainty*
    - Uncertainty for primary data was not quantified. However, the collected data and allocation methodologies were judged by the operations personnel to be accurate, so the uncertainty is considered low.

2.2 Secondary Data

Secondary data are derived from databases or outside sources and are used in the LCA software.

2.2.1 Data Sources

All secondary data were taken from literature, previous LCI studies, and life cycle databases. Each dataset used was taken from SimaPro databases, primarily USLCI (United States Life Cycle Inventory) or when USLCI datasets were not available, ecoinvent datasets were used instead. These databases are widely distributed and referenced within the LCA community and are either partially or fully critically reviewed.

The USLCI database (www.nrel.gov/lci) is used in this analysis. Much of the LCI data residing in the USLCI database pertains to common fuels – their combustion in utility, stationary and mobile equipment inclusive of upstream or pre-combustion effects (i.e., back to earth). Generally, these modular data are of a recent vintage. This study draws on these data for combustion processes, electricity generation, and transportation on a regional North American basis. These data were free and publicly available, and thus, offer both a high degree of transparency and an ability to replicate the results of the study. However, there are limitations, as some processes are missing for some of the products available in this LCI database, creating an issue with respect to completeness.

The ecoinvent LCI database is primarily utilized for secondary data in this study. This database contains over 20,000 LCI modules for processes and products, all of which have undergone peer review. The basic assumption when using these data are that North American and European production processes are generally similar.

Additionally, the EPA's AP 42 standard was used as a source of data for the air emissions from the process chemical reaction that occurs during brick manufacturing.

2.2.2 Data Quality

Secondary data sets were used for raw materials extraction and processing, end-of-life, transportation, and energy production flows. Wherever secondary data are used, the study adopts critically reviewed data for consistency, precision, and reproducibility to limit uncertainty. The data sources used are complete and representative of the United States in terms of the geographic and technological coverage and are a recent vintage (i.e., less than ten years old). Any deviations from these initial data quality requirements for secondary data are documented in the report. The most significant deviation is datasets that are more than ten years old. These datasets were chosen in order to use USLCI processes in alignment with the EPA PCR criteria.[3]

The results of an LCA are only as good as the quality of input data used. Important data quality factors include precision (measured, calculated, or estimated), completeness (e.g., unreported emissions or excluded flows), consistency (uniformity of the applied methodology throughout the study), and reproducibility (ability for another researcher to reproduce the results based on the methodological information provided). Each dataset used was taken from published databases, either USLCI or ecoinvent. These databases are widely distributed and referenced within the LCA community and are either partially or fully critically reviewed.

- *Precision*
  - USLCI - Precision for the datasets used from the USLCI database was not formally quantified. However, many data sets from the USLCI were developed based on well-documented industry averages with data quality indicators provided for each flow.
  - ecoinvent - Since the inventory flows for ecoinvent processes are very often accompanied by a series of data quality ratings, a general indication of precision can be inferred. Using these ratings, the data sets used generally have medium-to-high precision.
- *Completeness*
  - The processes modeled represent the specific situations in the clay brick assembly life cycle. System boundaries and exclusions are clearly defined in the sections above, and no other data gaps were identified. Where secondary datasets for specific materials or processes did not exist, proxy data were used to model the raw material extraction and processing. See Appendix B for the complete list of sources.
- *Consistency*
  - Secondary data was consistently modeled using either USLCI or ecoinvent databases as available. Proxies were only identified and used if secondary data were not available in these or other databases. This methodology provides consistency throughout the model.
- *Reproducibility*
  - Most datasets are from nationally accepted and publicly available databases, ensuring reproducibility by an average practitioner. Confidential data from the plant would inhibit reproducing these results without access to the data.
- *Representativeness*
  - The representativeness of the datasets was chosen to be representative of the United States in which the manufacturer resides and technologies that are representative of the manufacturer's facility. The temporal context of the datasets were also chosen to match the production as closely as possible.
- *Uncertainty*
  - Most of the secondary data sets in USLCI/ecoinvent databases have some uncertainty information documented and varies per model. The uncertainty of each dataset is not formally quantitatively known. Since the inventory flows for ecoinvent

[3] U.S. EPA Criteria for Product Category Rules (PCRs) to Support the Label Program for Low Embodied Carbon Construction Materials (EPA's PCR Criteria). Office of Chemical Safety and Pollution Prevention. EPA-740-R-24-009. Version 1. August 2024.

processes are very often accompanied by a series of data quality ratings, a general indication of uncertainty can be inferred. Using these ratings, the datasets used generally have fair to very good precision.

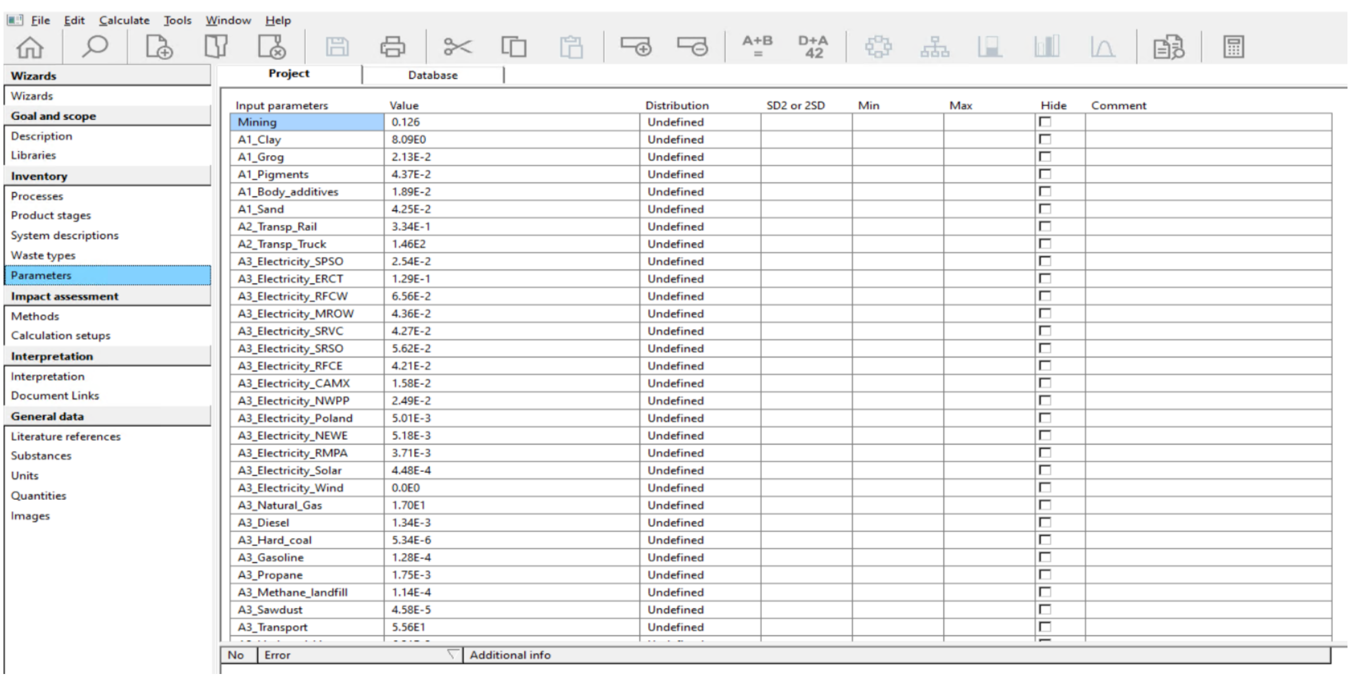
2.3 Modeling Software

SimaPro v9.6 software was utilized for modeling the complete cradle-to-grave LCI for Pacific Clay clay brick assemblies. SimaPro was used to generate life cycle impact assessment (LCIA) results utilizing the TRACI v2.2 impact assessment methodology. See Section 3.0 for a description of the selected LCIA categories and characterization measures used in this study.

2.4 EPD Generator Tool

This study will serve as the basis for a parameterized LCA generator model and tool. This Excel-based tool developed by Sustainable Solutions Corporation will allow BIA and its member companies to determine a set of parameters for baseline brick products. The parameters are determined by facility LCI information which are stored within the Excel file and may be averaged based on the input of the user. This primary data serves as an input into the EPD. Specific security measures are in place to prevent tampering and ensure accurate results. All cells that contain calculations or information that is not directly input from the user will be locked with a password that is not available to the user. The only agency from the user is the parameters set to describe the technical information of the product in question (including the contributing facilities), and the pasting of the results from the model.

Figure 2.1 shows an incomplete list of the parameters for the EPD generator in the SimaPro LCA modelling software.



Input parameters	Value	Distribution	SD2 or 2SD	Min	Max	Hide	Comment
Mining	0.126	Undefined					
A1_Clay	8.09E0	Undefined					
A1_Grog	2.13E-2	Undefined					
A1_Pigments	4.37E-2	Undefined					
A1_Body_additives	1.89E-2	Undefined					
A1_Sand	4.25E-2	Undefined					
A2_Transp_Rail	3.34E-1	Undefined					
A2_Transp_Truck	1.46E2	Undefined					
A3_Electricity_SPSO	2.54E-2	Undefined					
A3_Electricity_ERCT	1.29E-1	Undefined					
A3_Electricity_RFCW	6.56E-2	Undefined					
A3_Electricity_MROW	4.36E-2	Undefined					
A3_Electricity_SRVC	4.27E-2	Undefined					
A3_Electricity_SRSO	5.62E-2	Undefined					
A3_Electricity_RFCE	4.21E-2	Undefined					
A3_Electricity_CAMX	1.58E-2	Undefined					
A3_Electricity_NWPP	2.49E-2	Undefined					
A3_Electricity_Poland	5.01E-3	Undefined					
A3_Electricity_NEWE	5.18E-3	Undefined					
A3_Electricity_RMPA	3.71E-3	Undefined					
A3_Electricity_Solar	4.48E-4	Undefined					
A3_Electricity_Wind	0.0E0	Undefined					
A3_Natural_Gas	1.70E1	Undefined					
A3_Diesel	1.34E-3	Undefined					
A3_Hard_coal	5.34E-6	Undefined					
A3_Gasoline	1.28E-4	Undefined					
A3_Propane	1.75E-3	Undefined					
A3_Methane_landfill	1.14E-4	Undefined					
A3_Sawdust	4.58E-5	Undefined					
A3_Transport	5.56E1	Undefined					

Figure 2.1 – LCA Parameters in SimaPro

After inputting the necessary values into the Excel generator tool, the user will copy and paste the parameters into SimaPro. The figure below gives an example of how the parameterized model is used to calculate results.

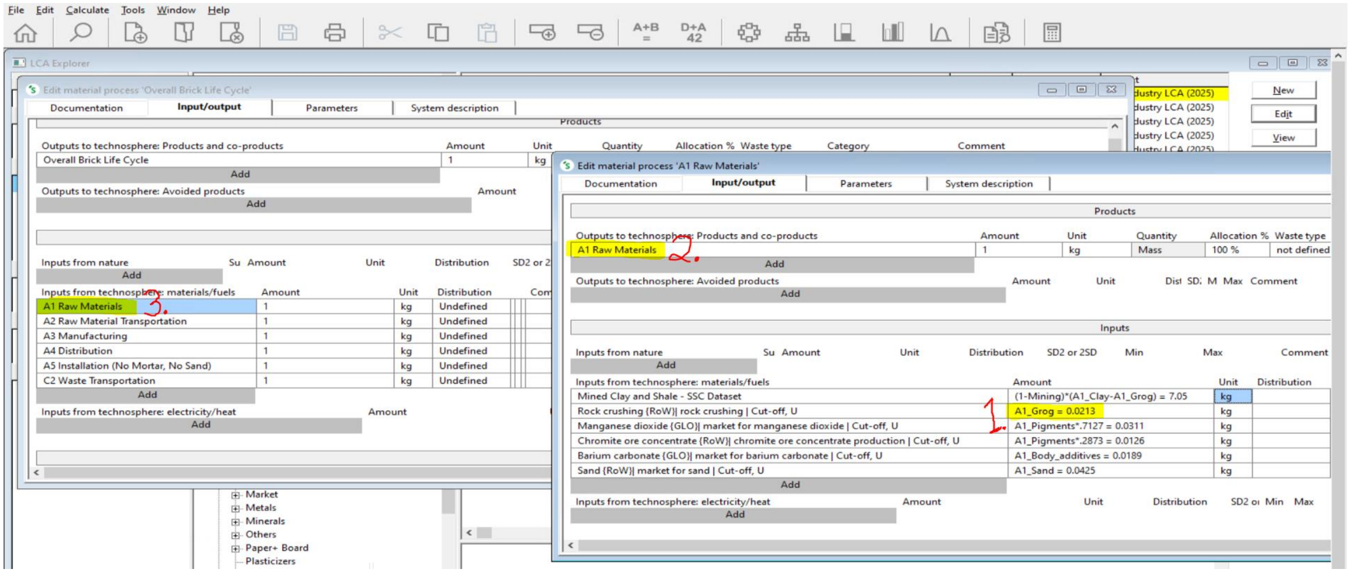


Figure 2.2 – Internal Model Parameter Mechanics

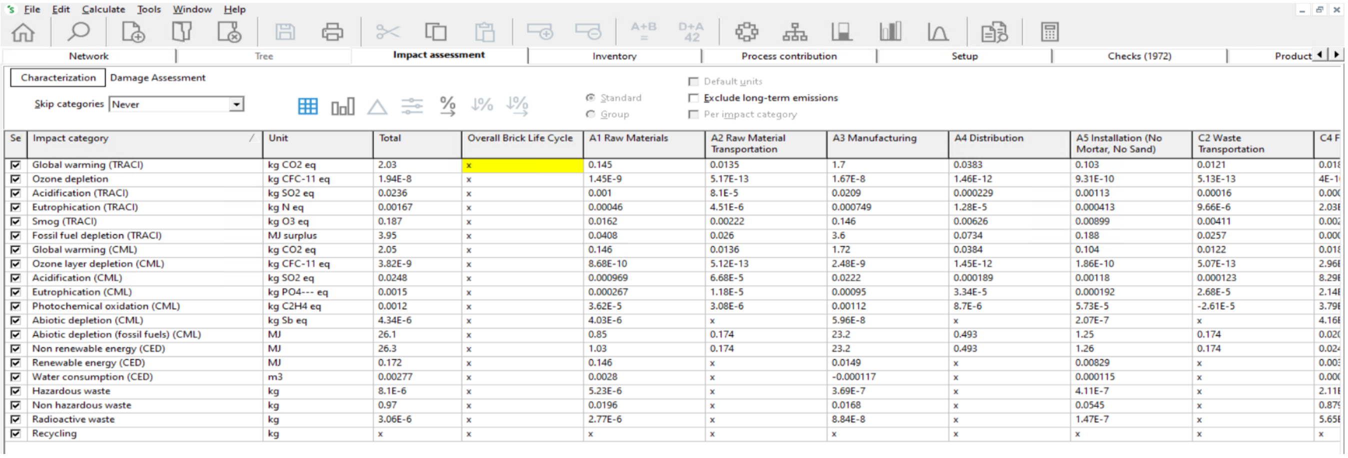
Model inputs are automatically populated throughout the model from the list of parameters.

1) Parameters are used in processes and are sometimes scaled to fit the requirements of the model. For example, "A1_Grog" is used as the value of the amount of raw material grog used in mass per kg of brick made.

2) Each lifecycle stage is a process that contains all required inputs and outputs of that stage, the values of which are determined by parameters or assumptions.

3) All lifecycle stages are combined in one process named "Overall Brick Life Cycle".

The overall process will be used to calculate the results of the LCIA. The results are accurate per kilogram of brick product. A custom LCIA method was used to evaluate all impact categories required by the EPD.



Se	Impact category	Unit	Total	Overall Brick Life Cycle	A1 Raw Materials	A2 Raw Material Transportation	A3 Manufacturing	A4 Distribution	A5 Installation (No Mortar, No Sand)	C2 Waste Transportation	C4 F
☑	Global warming (TRACI)	kg CO2 eq	2.03	x	0.145	0.0135	1.7	0.0383	0.103	0.0121	0.01
☑	Ozone depletion	kg CFC-11 eq	1.94E-8	x	1.45E-9	5.17E-13	1.67E-8	1.46E-12	9.31E-10	5.13E-13	4E-1
☑	Acidification (TRACI)	kg SO2 eq	0.0236	x	0.001	8.1E-5	0.0209	0.000229	0.00113	0.00016	0.00
☑	Eutrophication (TRACI)	kg N eq	0.00167	x	0.00046	4.51E-6	0.000749	1.28E-5	0.000413	9.66E-6	2.03
☑	Smog (TRACI)	kg O3 eq	0.187	x	0.0162	0.00222	0.146	0.00626	0.00899	0.00411	0.00
☑	Fossil fuel depletion (TRACI)	MJ surplus	3.95	x	0.0408	0.026	3.6	0.0734	0.188	0.0257	0.00
☑	Global warming (CML)	kg CO2 eq	2.05	x	0.146	0.0136	1.72	0.0384	0.104	0.0122	0.01
☑	Ozone layer depletion (CML)	kg CFC-11 eq	3.82E-9	x	8.68E-10	5.12E-13	2.48E-9	1.45E-12	1.86E-10	5.07E-13	2.96
☑	Acidification (CML)	kg SO2 eq	0.0248	x	0.000969	6.68E-5	0.0222	0.000189	0.00118	0.000123	8.29
☑	Eutrophication (CML)	kg PO4--- eq	0.0015	x	0.000267	1.18E-5	0.00095	3.34E-5	0.000192	2.68E-5	2.14
☑	Photochemical oxidation (CML)	kg C2H4 eq	0.0012	x	3.62E-5	3.08E-6	0.00112	8.7E-6	5.73E-5	-2.61E-5	3.79
☑	Abiotic depletion (CML)	kg Sb eq	4.34E-6	x	4.03E-6	x	5.96E-8	x	2.07E-7	x	4.16
☑	Abiotic depletion (fossil fuels) (CML)	MJ	26.1	x	0.85	0.174	23.2	0.493	1.25	0.174	0.02
☑	Non renewable energy (CED)	MJ	26.3	x	1.03	0.174	23.2	0.493	1.26	0.174	0.02
☑	Renewable energy (CED)	MJ	0.172	x	0.146	x	0.0149	x	0.00829	x	0.00
☑	Water consumption (CED)	m3	0.00277	x	0.0028	x	-0.000117	x	0.000115	x	0.00
☑	Hazardous waste	kg	8.1E-6	x	5.23E-6	x	3.69E-7	x	4.11E-7	x	2.11
☑	Non hazardous waste	kg	0.97	x	0.0196	x	0.0168	x	0.0545	x	0.87
☑	Radioactive waste	kg	3.06E-6	x	2.77E-6	x	8.84E-8	x	1.47E-7	x	5.65
☑	Recycling	kg	x	x	x	x	x	x	x	x	x

Figure 2.3 – Example of SimaPro Results of Overall Lifecycle Process

These results are then pasted into the generator tool. The EPD is populated exclusively from the user inputs, the locked calculations, and the results inputs directly from the model. All else is locked and/or password protected. SSC analysts will be the operators of the BIA EPD generator. It is our responsibility to input the product's values correctly, to operate SimaPro, and to paste the results correctly into the generator tool. The parameterized LCA model is static other than the generated parameters, so the results can be recreated given the set of parameters which can be found in Appendix D: EPD Generator Parameters.

3.0 Life Cycle Impact Assessment (LCIA)

The environmental impacts of a product can be categorized and presented in many ways. This section describes the methodology used to develop the impact assessment and defines the selected impact categories used to present the results. This section also lists assumptions of the study and describes the inherent limitations and uncertainty of the LCA results.

3.1 Impact Categories/Impact Assessment

As defined in ISO 14040:2006, "the impact assessment phase of an LCA is aimed at evaluating the significance of potential impacts using the results of the LCI analysis". In the LCIA phase, SSC modeled a set of selected environmental issues referred to as impact categories and used category indicators to aggregate similar resource usage and emissions to explain and summarize LCI results data. These category indicators are intended to characterize the relevant environmental flows for each environmental issue category to represent the potential or possible environmental impacts of a product system. The LCIA results are relative expressions and do not predict impacts on category endpoints or the exceeding of thresholds, safety margins, or risk.

ISO 14044 does not specify any specific methodology or support the underlying value choices used to group the impact categories. The value-choices and judgments within the grouping procedures are the sole responsibilities of the commissioner of the study.

The framework surrounding LCIA includes three steps that convert LCI results to category indicator results. These include the following:

1. Selection of impact categories, category indicators, and models.
2. Assignment of the LCI results to the impact categories (classification) – the identification of individual inventory flow results contributing to each selected impact indicator.
3. Calculation of category indicator results (characterization) – the actual calculation of the potential or possible impact of a set of inventory flows identified in the previous classification step.

To maximize the reliability and flexibility of the results, SSC used an established impact methodology for assigning and calculating impacts. The Tools for Reduction and Assessment of Chemical and other environmental Impacts (TRACI) methodology was used for all calculations of environmental impact. TRACI was developed by the U.S. EPA to assist in impact analysis in Life Cycle Assessments, process design, and pollution prevention. A 100-year time period is assumed in the impact assessment methodology for inputs and outputs for the product system.

3.2 Selected Impact Categories

While LCI practice holds to a consistent methodology, the LCIA phase is an evolving science and there is no overall generally accepted methodology for calculating all of the impact categories that might be included in an LCIA. Typically, the LCIA is completed in isolation of the LCI. The LCI involves the collection of a complete mass and energy balance for each unit process under consideration. Once completed, the LCI flows are sent through various possible LCIA indicator methods and categories to determine possible impacts. Due to the North American focus of this LCA study, the TRACI v2.2 methodology was used to characterize the study's LCI flows. Impact categories include:

1. *Ozone depletion* (kg CFC-11 eq) – Certain chemicals, when released into the atmosphere, can cause depletion of the stratospheric ozone layer, which protects the Earth and its inhabitants from ultraviolet radiation. This radiation can have a negative impact on crops, materials, and marine life, as well as contributing to cancer and cataracts. This impact measures the release of those chemicals.

2. *Global Warming Potential* (kg CO_2 eq) – The methodology and science behind the Global Warming Potential calculation can be considered one of the most accepted LCIA categories. Global Warming Potential allows impact comparison of different gases on the same scale. Because this study also tracks an overall life cycle carbon balance, the carbon dioxide emissions associated with biomass combustion are included in the Global Warming Potential calculation, but the sequestering of carbon is treated as a negative emission in the calculation as per the IPCC methodology. Carbon dioxide and other greenhouse gases are emitted at every stage in the manufacturing process. These gases can trap heat close to the Earth, contributing to Global Warming Potential.

3. *Smog* (kg O_3 eq) – Under certain climatic conditions, air emissions from industry and transportation can be trapped at ground level where, in the presence of sunlight, they produce photochemical smog, a symptom of photochemical ozone creation potential. While ozone is not emitted directly, it is a product of interactions of volatile organic compounds (VOCs) and nitrogen oxides (NOx). The Smog indicator is expressed as a mass of equivalent ozone (O_3).

4. *Acidification* (kg SO_2 eq) – Acidification is a more regional rather than global impact. It affects fresh water and forests as well as human health when high concentrations of SO_2 are attained in the environment. Acidification is a result of processes that contribute to

increased acidity of water and soil systems, frequently through air emissions that contribute to acid rain. The largest contributors to acid rain are sulfur dioxide and nitrogen oxide.

5. *Freshwater Eutrophication* (kg P eq) – Eutrophication is the fertilization of surface waters by an excess of nutrients. When a nutrient is added to a water body, it leads to a large increase in aquatic plant life. This may lead to the water body becoming hypoxic, eventually causing the death of fish and other aquatic life. This impact is expressed on an equivalent mass of nitrogen (N) basis.
6. *Marine Eutrophication* (kg N eq) – Eutrophication is the fertilization of surface waters by an excess of nutrients. When a nutrient is added to a water body, it leads to a large increase in aquatic plant life. This may lead to the water body becoming hypoxic, eventually causing the death of fish and other aquatic life. This impact is expressed on an equivalent mass of nitrogen (N) basis.

These six impact categories are globally deemed mature enough to be included in Type III environmental declarations. Other categories are being developed and defined and LCA should continue making advances in their development. However, the EPD users shall not use additional measures for comparative purposes.

4.0 Life Cycle Inventory

4.1 A1 Raw Materials

Allocation was conducted on a per square meter basis based on the consumption of materials over the reference calendar year 2023. Materials were tracked based on annual consumption and production quantities, except for mined clay and shale material, allowing for allocating materials to clay brick assembly production. The manufacturer does not own its mining operations, so secondary data was used for this data. The clay and shale material consumed per kg of fired brick is equal to 1.258 kg, as per the PCR.

The pigments modeled in the study were based on commonly used pigments provided by the PCR. The pigments in Pacific Clay manufacturing were modeled as:

- Manganese dioxide/Manganese (III) oxide [71.27%] – modeled as Manganese dioxide {GLO}| market for manganese dioxide | Cut-off, U.
- Iron chromite [28.73%] – Chromite ore concentrate {RoW}| chromite ore concentrate production | Cut-off, U.

Product recipes are listed in Table 4.1.

Table 4.1 – Raw Materials Formulation

Material	Unit	Clay Brick & Structural Clay Tile	Clay Brick Paver	Thin Brick
Mined Clay and Internal Grog	kg/m^2	1.60E+02	2.33E+02	1.87E+02
External Grog	kg/m^2	4.09E+00	5.98E+00	4.78E+00
Pigments	kg/m^2	6.23E-01	9.11E-01	7.29E-01
Body Additives	kg/m^2	4.36E-01	6.38E-01	5.10E-01
Sand	kg/m^2	0.00E+00	0.00E+00	0.00E+00
Total	**kg/m^2**	**1.65E+02**	**2.41E+02**	**1.93E+02**

Mined clay and internal grog are aggregated in the raw material formulation because mined clay that is used in the process becomes internal grog when the scrap material is recycled back into the process. External grog is separated because external grog does not come from the facilities process and is therefore treated as secondary burden with no raw material impact in the model.

4.2 A2 Raw Material Transportation

To obtain the materials in Table 4.1 a mix of transit modes are used to supply the materials including rail and truck. The following table details the total transportation for the raw materials based on the distances from suppliers and the amounts used by each facility. The datasets used to model transportation include average data to incorporate backhauls in the process inputs.

Table 4.2 – Raw Material Transportation

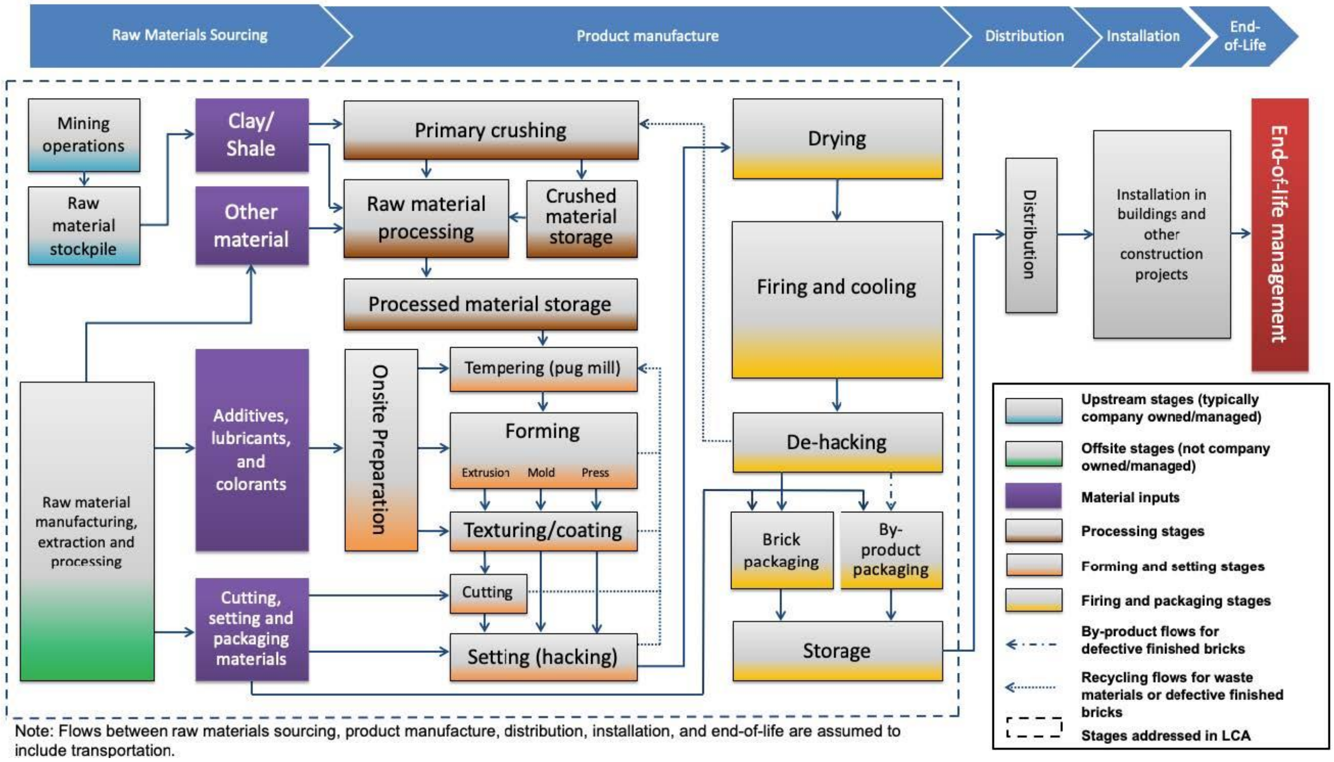
Transport Mode	Unit	Clay Brick & Structural Clay Tile	Clay Brick Paver	Thin Brick
Rail	kgkm/m^2	0.00E+00	0.00E+00	0.00E+00
Truck	kgkm/m^2	2.72E+03	3.98E+03	3.18E+03
Total	**kgkm/m^2**	**2.72E+03**	**3.98E+03**	**3.18E+03**

Transportation distances for brick manufacturing are significantly low, relative to normal raw material transportation. Raw material transportation values were calculated based on facility-specific suppliers.

4.3 A3 Manufacturing

Clay brick assemblies produced by Pacific Clay in 2023 follow similar manufacturing processes. The production process outlined below is described as according to the BIA Technical Note on Brick Manufacturing.[4]

[4] Manufacturing of Brick. Technical Notes on Brick Construction. The Brick Industry Association. December 2006. Volume 9.



1. **Mining and Storage:** Surface clays, shales and some fire clays are mined in open pits with power equipment. Then the clay or shale mixtures are transported to plant storage areas. Continuous brick production regardless of weather conditions is ensured by storing sufficient quantities of raw materials required for many days of plant operation. Normally, several storage areas (one for each source) are used to facilitate blending of the clays. Blending produces more uniform raw materials, helps control color and allows raw material control for manufacturing a certain brick body.
2. **Preparation:** To break up large clay lumps and stones, the material is processed through size-reduction machines before mixing the raw material. Usually, the material is processed through inclined vibrating screens to control particle size.
3. **Forming:** Tempering, the first step in the forming process, produces a homogeneous, plastic clay mass. Usually, this is achieved by adding water to the clay in a pug mill. After pugging, the plastic clay mass is ready for forming. Two main processes for forming are considered in this study: stiff-mud and soft-mud.
    a. **Stiff-Mud Process:** In the stiff-mud or extrusion process, water in the range of 10 to 15 percent is mixed into the clay to produce plasticity. After pugging, the tempered clay goes through a de-airing chamber that maintains vacuum. De-airing removes air holes and bubbles, giving the clay increased workability and plasticity, resulting in greater strength. Next, the clay is extruded through a die to produce a column of clay. As the clay column leaves the die, textures or surface coatings may be applied. An automatic cutter then slices through the clay column to create individual bricks. Cutter spacings and die sizes must be carefully calculated to compensate for normal shrinkage that occurs during drying and firing.
    b. **Soft-Mud Process:** The soft-mud or molded process is particularly suitable for clays containing too much water to be extruded by the stiff-mud process. Clays are mixed

to contain 20 to 30 percent water and then formed into brick in molds. To prevent clay from sticking, the molds are lubricated with either sand or water to produce "sand-struck" or "water-struck" brick. Brick may be produced in this manner by machine or by hand.

4. **Drying:** Before the firing process begins, most of the water is evaporated in dryer chambers at temperatures ranging from about 100 ºF to 400 ºF (38 ºC to 204 ºC). The extent of drying time, which varies with different clays, usually is between 24 to 48 hours. Although heat may be generated specifically for dryer chambers, it usually is supplied from the exhaust heat of kilns to maximize thermal efficiency. In all cases, heat and humidity must be carefully regulated to avoid cracking in the brick.
5. **Hacking:** Hacking is the process of loading a kiln car or kiln with brick. The number of brick on the kiln car is determined by kiln size. The bricks are typically placed by robots or mechanical means.
6. **Firing:** Brick are fired between 10 and 40 hours, depending upon kiln type and other variables. There are several types of kilns used by manufacturers. The most common type is a tunnel kiln, followed by periodic kilns. Fuel may be natural gas, coal, sawdust, methane gas from landfills or a combination of these fuels. In a tunnel kiln, brick are loaded onto kiln cars, which pass through various temperature zones as they travel through the tunnel. The heat conditions in each zone are carefully controlled, and the kiln is continuously operated. Firing may be divided into five general stages: 1) final drying (evaporating free water); 2) dehydration; 3) oxidation; 4) vitrification; and 5) flashing or reduction firing. All except flashing are associated with rising temperatures in the kiln. Final drying takes place at temperatures up to about 400 ºF (204 ºC), dehydration from about 300 ºF to 1800 ºF (149 ºC to 982 ºC), oxidation from 1000 ºF to 1800 ºF (538 ºC to 982 ºC) and vitrification from 1600 ºF to 2400 ºF (871 ºC to 1316 ºC). Clay, unlike metal, softens slowly and melts or vitrifies gradually when subjected to rising temperatures. Vitrification allows clay to become a hard, solid mass with relatively low absorption. Near the end, the brick may be "flashed" to produce color variations.
7. **Cooling:** After the temperature has peaked and is maintained for a prescribed time, the cooling process begins. Cooling is an important stage in brick manufacturing because the rate of cooling has a direct effect on color.
8. **De-hacking:** De-hacking is the process of unloading a kiln or kiln car after the bricks have cooled, a job often performed by robots. Bricks are sorted, graded and packaged. Then they are placed in a storage yard or loaded onto rail cars or trucks for delivery. The majority of brick today are packaged in self-contained, strapped cubes, which can be broken down into individual strapped packages for ease of handling on the jobsite. The packages and cubes are configured to provide openings for handling by forklifts, thus being ready for shipment.

Allocation of manufacturing inputs to each facility's brick products was conducted using the guidance of ISO 21930. Since the majority of energy is used in the firing of brick products, the inputs were allocated evenly over the fired brick weight production. Energy usage did not depend on brick specifications (such as pigment usage or shape) so the allocation over mass is not expected to introduce error. All secondary manufacturing materials in the process are accounted for based on mass allocation.

Table 4.3 below details the manufacturing inventory for Pacific Clay clay brick assembly production. Primary Emission data were not available, so the default values listed in the PCR were used instead and are listed below. The values provided are per functional unit, however, they only reflect the manufacturing of the brick product in the functional unit.

Secondary fuels (methane from landfill and sawdust) were considered no burden to the product system, and only emissions from combustion were modeled.

The EPA's AP 42 standard[5] was used to determine the process emissions within the inventory. This standard is fairly outdated but still used as the reference standard for manufacturing emissions within the brick industry. The SP 42 standard outlines default values for pounds of emissions per fired ton for a number of chemical emissions. Based on BIA industry expert advice, SSC determined that fuel emissions are included in the values stated for carbon dioxide, methane, and NOx. The emissions due to fuel combustion were subtracted from the AP 42 emissions to calculate emissions only relevant for the process chemistry emissions. The fuel combustion emissions based on primary facility data were then added back in. Facilities that were able to report their process emissions typically have implemented process control systems to reduce these emissions. The standard AP 42 emissions were assumed for all facilities unable to report their emissions. The industry average of these emissions was determined using the method described in Section 1.4.

Table 4.3 – Manufacturing Inventory

Energy	Unit	Clay Brick & Structural Clay Tile	Clay Brick Paver	Thin Brick
Electricity	kWh/m²	1.18E+01	1.72E+01	1.38E+01
Natural Gas	m³/m²	1.13E+01	1.66E+01	1.33E+01
Diesel	L/m²	1.31E-01	1.92E-01	1.54E-01
Hard Coal	MT/m²	0.00E+00	0.00E+00	0.00E+00
Gasoline	L/m²	4.19E-03	6.12E-03	4.89E-03
Propane	L/m²	1.77E-01	2.59E-01	2.07E-01
Methane (landfill)	L/m²	0.00E+00	0.00E+00	0.00E+00
Sawdust	MT/m²	0.00E+00	0.00E+00	0.00E+00
Transport	**Unit**	**Structural Clay Brick**	**Clay Brick Paver**	**Thin Brick**
Transportation	kgkm/m²	2.70E+03	3.94E+03	3.15E+03
Support Materials	**Unit**	**Structural Clay Brick**	**Clay Brick Paver**	**Thin Brick**
Hydrated Lime	kg/m²	0.00E+00	0.00E+00	0.00E+00
Limestone	kg/m²	0.00E+00	0.00E+00	0.00E+00
Sodium Bicarbonate	kg/m²	0.00E+00	0.00E+00	0.00E+00
White Mineral Oil	kg/m²	0.00E+00	0.00E+00	0.00E+00
Water	**Unit**	**Clay Brick & Structural Clay Tile**	**Clay Brick Paver**	**Thin Brick**
Tap Water	L/m²	2.28E+01	3.33E+01	2.66E+01
Well Water	L/m²	0.00E+00	0.00E+00	0.00E+00

[5] 11.3 Brick and Structural Clay Product Manufacturing. AP 42: Air Emissions Factors and Quantification. Environmental Protection Agency. Volume I, Chapter 11: Mineral Products Industry. 1995. Accessed on March 3, 2025. https://www3.epa.gov/ttnchie1/ap42/ch11/final/c11s03.pdf

Packaging	Unit	Clay Brick & Structural Clay Tile	Clay Brick Paver	Thin Brick
Plastic	kg/m^2	3.12E-02	4.56E-02	3.65E-02
Steel	kg/m^2	3.57E-04	5.21E-04	4.17E-04
Paper	kg/m^2	2.03E-02	2.97E-02	2.37E-02
Wood	m^3/m^2	0.00E+00	0.00E+00	0.00E+00
Pallets	m^3/m^2	2.52E-03	3.68E-03	2.94E-03
Waste	**Unit**	**Structural Clay Brick**	**Clay Brick Paver**	**Thin Brick**
Non-hazardous	kg/m^2	3.14E-01	4.59E-01	3.67E-01
Hazardous	kg/m^2	0.00E+00	0.00E+00	0.00E+00
Wastewater	L/m^2	2.19E+01	3.20E+01	2.56E+01
Emissions	**Unit**	**Structural Clay Brick**	**Clay Brick Paver**	**Thin Brick**
Carbon Dioxide	kg/m^2	4.36E+00	6.37E+00	5.10E+00
Carbon Monoxide	kg/m^2	6.93E-03	1.01E-02	8.10E-03
Chlorine	kg/m^2	8.25E-05	1.21E-04	9.65E-05
Hydrogen Chloride	kg/m^2	1.08E-02	1.58E-02	1.26E-02
Hydrogen Fluoride	kg/m^2	2.35E-02	3.43E-02	2.75E-02
Lead	kg/m^2	2.07E-08	3.02E-08	2.41E-08
Mercury	kg/m^2	4.76E-07	6.96E-07	5.56E-07
Methane	kg/m^2	4.58E-04	6.70E-04	5.35E-04
Nitrogen Dioxide	kg/m^2	0.00E+00	0.00E+00	0.00E+00
Nitrogen Oxides	kg/m^2	1.65E-02	2.41E-02	1.92E-02
Particulate Matter - PM2.5	kg/m^2	1.47E-03	2.15E-03	1.72E-03
Particulate Matter - PM10	kg/m^2	2.94E-03	4.30E-03	3.44E-03
Sulfur Dioxide	kg/m^2	1.19E-04	1.74E-04	1.39E-04
VOC (unspecified)	kg/m^2	1.31E-02	1.91E-02	1.53E-02

4.4 A4 Distribution

Clay brick assemblies are manufactured by Pacific Clay and are sold all across the United States. The default transportation distance for clay brick assemblies was employed, per the PCR. Table 4.4 outlines the distribution inventory for clay brick assemblies manufactured by Pacific Clay.

Table 4.4 – Distribution Inventory

	Unit	Clay Brick & Structural Clay Tile	Clay Brick Paver	Thin Brick
Fuel type	-	Diesel	Diesel	Diesel
Liters of fuel	L / 100km-kg	2.72E-03	2.72E-03	2.72E-03
Vehicle type	-	Combination Truck	Combination Truck	Combination Truck
Transport distance	km	4.07E+02	4.07E+02	4.07E+02
Capacity utilization (including empty runs, mass based	%	4.99E+01	4.99E+01	4.99E+01
Gross density of products transported	kg/m³	1.99E+03	1.99E+03	1.99E+03
Weight of products transported (if gross density not reported)	kg	-		
Volume of products transported (if gross density not reported)	m³	-		
Capacity utilization volume factor (factor: =1 or <1 or ≥ 1 for compressed or nested packaging products)	-	<1		

4.5 A5 Installation

The installation of clay brick assemblies differs for products wall application brick (Clay Brick & Structural Clay Tile and Thin Brick) versus Clay Brick Pavers.

The installation of Clay Brick & Structural Clay Tile and Thin Brick requires the use of a masonry mortar to form the 3/8" joint per the functional unit. Masonry mortar as defined by ASTM C91 is considered a proprietary material by manufacturers. The composition of masonry mortar was implemented as outlined in the PCR and is outlined in Table 4.7.

The installation of Clay Brick Pavers requires the use of concrete sand to form the 1/8" joint per the functional unit. Concrete sand is defined by ASTM C33. The composition of concrete sand was implemented as outlined in the PCR and is outlined in Table 4.7.

The mass of masonry mortar/concrete sand necessary to satisfy the functional unit used to following formula:

$$\text{Mass of Mortar/Sand} = [1\ m^2 * W - (W * H * L) * u_b] * d_{m/s}$$

where,

W = Bed Depth (m)
H = Brick Height (m)
L = Brick Length (m)
J = Mortar Joint (m)
d_m = Mortar Density (kg/m^3) = 1944.4 kg/m^3
d_s = Sand Density (kg/m^3) = 1601.9 kg/m^3
u_b = Brick Units to Fulfill Functional Unit = $\frac{1}{(H+J)*(L+J)}$

During installation, the packaging for clay brick assemblies must be removed and disposed. The disposal of these materials was assumed to follow the end-of-life pathways as dictated by the most recent EPA waste statistics.[6,7] There was an assumed 5% product mass loss and 10% mortar mass loss during the installation process, as determined by the PCR. The resulting disposal of these materials follows the most recent EPA Construction & Demolition Waste statistics.[8]

Installation support materials fall outside of the control of Pacific Clay, as such the following assumptions were implemented:

- Masonry mortar (as defined by ASTM C91) was determined to be the only installation item that was relevant for reporting, above the cut-off criteria outlined in Section 1.7. The impact of the electricity required to mix the mortar as well as the sand for Clay Brick Paver installation were determined to be below the cut-off criteria and thus excluded from the scope of the study.
    - The electricity required for mixing the mortar at the installation site was calculated to be 0.03 kWh per square meter (requiring five minutes of mixing using a ½ horsepower motor). The time and motor specification were based on technical data sheets pulled from manufacturers within the mortar industry.[9]
    - The mortar mix ratio was assumed to be 1 part water to 5 parts dry mortar mix (by mass) in accordance with the PCR specifications.
    - Mortar installation scrap rate of 10% was applied.
    - The average density of masonry mortar is 1944.4 kg/m^3.
    - Thin brick installation requires a 1/8" mortar joint on the bed side (back layer of the brick) to be adhered to the wall.

[6] EPA Materials Management 2014 Fact Sheet, Table 2: https://www.epa.gov/sites/production/files/2016-11/documents/2014_smmfactsheet_508.pdf. (Accessed March 2025).

[7] EPA National Overview: Facts and Figures on Materials, Wastes and Recycling. https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/national-overview-facts-and-figures-materials#recycling. (Accessed March 2025).

[8] Construction and Demolition Debris Management in the United States, 2015 U.S. Environmental Protection Agency Office of Resource Conservation and Recovery March 2020

[9] Product Data Sheet: King 1-1-6. Sika Canada, Inc. June 2024, Version 01.03.

- Only manual cleaning is required during installation, and it is a non-significant impact, so it is excluded from the study.

In addition, sand used in the joint for clay brick paver installation was deemed negligible. Energy use for mixing the mortar used for installation was also deemed negligible.

Table 4.5 – Product Disposal Assumptions

End-of-Life Pathway	Mass Percentage
Landfill	87.0%
Recycle	0.0%
Reuse	13.0%
Incineration	0.0%
Incineration with Energy Recovery	0.0%

Table 4.6 – Packaging Disposal Assumptions

End-of-Life Pathway	Plastics	Metals	Pulp (cardboard, paper)	Wood
Landfill	74.0%*	34.0%	27.0%*	27.0%*
Recycle	9.0%	57.0%	68.0%	68.0%
Incineration	17.0%	9.0%	5.0%	5.0%

**Materials with sums of disposal pathways less than 100% were adjusted to equal 100%. The remaining percentage was added to the landfill pathway percentage to be conservative in the approach.*

Table 4.7 – Installation Inventory

		Unit	Clay Brick & Structural Clay Tile	Clay Brick Paver	Thin Brick
Ancillary materials	Mortar	kg/m^2	2.73E+01	0.00E+00	9.85E+00
	Water	kg/m^2	5.46E+00	0.00E+00	1.97E+00
	Other	kg/m^2	0.00E+00	0.00E+00	0.00E+00
Net freshwater consumption specified by water source and fate (amount evaporated, amount disposed to sewer)	N/A - manual cleaning during construction	kg/m^2	-	-	-
Electricity consumption	-	kg/m^2	3.11E-02	0.00E+00	3.11E-02
Product loss per functional unit	5% product scrap default assumption	kg/m^2	6.35E+00	9.28E+00	1.33E+00
Waste materials at the construction site before waste processing, generated by product installation	-	kg/m^2	1.48E+01	1.69E+01	8.60E+00

Output materials resulting from on-site waste processing (specified by route; e.g. for recycling, energy recovery and/or disposal)	Product - Landfill	kg/m²	5.52E+00	8.07E+00	1.16E+00
	Product - Recycle	kg/m²	0.00E+00	0.00E+00	0.00E+00
	Product - Reuse	kg/m²	8.25E-01	1.21E+00	1.73E-01
	Product - Incineration	kg/m²	0.00E+00	0.00E+00	0.00E+00
	Packaging - Landfill	kg/m²	6.55E-01	9.58E-01	7.66E-01
	Packaging - Recycle	kg/m²	1.60E+00	2.33E+00	1.86E+00
	Packaging - Incineration	kg/m²	1.22E-01	1.79E-01	1.43E-01
Biogenic carbon contained in packaging	-	kg/m²	1.17E+00	1.71E+00	1.37E+00
VOC content	-	µg/m³	-	-	-

4.6 B Use Stage

The reference service life (RSL) of clay brick assemblies is 150 years; however, since the estimated building service life (ESL) in North America is commonly accepted as 75 years, there are no replacements necessary over the life cycle of clay brick assemblies. The selected service life used in the project reflects the expert opinions of the product manufacturers and is typical of industry assumptions. There are no impacts for clay brick assemblies during the following stages: Use (B1), Repair (B3), Refurbishment (B5), Operational Energy Use (B6), and Operational Water Use (B7).

During the use stage, the Clay Brick Paver products are the only product type that require meaningful cleaning and this is as a result of aesthetic upkeep, not functional performance. For the cleaning process, several assumptions were enforced, all in alignment with the PCR:

- Biennial cleaning, therefore, there are 75 cleaning cycles over the course of the RSL.
- The two main methods for cleaning are sweeping (manual, only requiring human effort which is not captured in this study, therefore no impact) and cleaning with a cleaning solution and pressure washer.
- Brick paving solutions are often considered proprietary and thus need to be modeled for the specific application. The common composition was modeled as:
  - Water – 80%.
  - NMD 80 (hydrochloric acid) – 20%.
- The pressure washing process uses 0.08 kWh of electricity per square meter and 0.009 cubic meters of water per square meter.

There are no maintenance requirements for Clay Brick & Structural Clay Tile and Thin Brick; however, Clay Brick Pavers are frequently cleaned for aesthetic appeal. Table 4.8 and Table 4.9 outline the maintenance and replacement inventories for each of the product systems.

Table 4.8 – Maintenance Inventory

		Unit	Clay Brick Paver
Maintenance process information (cite source in report)	-	-	Maintenance of Clay Pavers using pressurized water requires a cleaning solution, of 1 part cleaning agent to 4 parts water, to be prepared and sprayed on the target area. The acid used in most proprietary cleaning products is highly buffered and diluted as part of their proprietary mix. The solution should set for 5-7 minutes, before using a pressure washer (average 13hp, pressure not to exceed 800 psi) to clear the solution from the target area.
Maintenance cycle	-	Number/ RSL	37.5
Maintenance cycle	-	Number/ ESL	18.75
Net freshwater consumption specified by water source and fate (amount evaporated, amount disposed to sewer)	Tap water	m^3/m^2	9.46E-03
Ancillary materials specified by type (e.g. cleaning agent)	Cleaning agent (proprietary diluted acid)	kg/m^2	6.23E-02
	Water (cleaning solution)	kg/m^2	2.17E-01
Energy input, specified by activity, type and amount	Energy for pressure washing	kWh/m^2	8.08E-02
Power output of equipment	-	kW	9.69E+00
Waste materials from maintenance (specify materials)	-	kg/m^2	-

Table 4.9 – Replacements Inventory

	Unit	Clay Brick & Structural Clay Tile	Clay Brick Paver	Thin Brick
Reference Service Life (RSL)	years	150	150	150
Estimated Service Life (ESL)	years	75	75	75
Number of Replacements	-	0	0	0

4.7 C End-of-Life Stage

The end-of-life scenario was modeled based on the EPA Waste statistics that were outlined in Section 4.5. Clay brick assemblies are standard materials in construction projects; thus, the EPA waste statistics represent an accurate depiction of how the materials are disposed. The distance to disposal site for all waste is 32 km. Module C includes waste processing, emissions/loads from all end-of-life modules, wastes leaving as secondary materials, collection and transport, and emissions from landfills accumulated over 100 years after disposal. Table 4.10 details the disposal assumptions and inventory of clay brick assemblies.

Table 4.10 – End-of-Life Inventory

		Unit	Clay Brick & Structural Clay Tile	Clay Brick Paver	Thin Brick
Assumptions for scenario development (description of deconstruction, collection, recovery, disposal method and transportation)	Clay Brick & Structural Clay Tiles, Clay Brick Pavers, and Thin Brick are collected separately from mixed construction waste in the demolition stage. Demolition and collection require no additional considerations from normal demolition; therefore, demolition impacts are de minimis. Upon collection, 13% of the product (by mass) is reused in the form of bulk aggregate to offset virgin material in the next product lifetime, with the remaining 87% being landfilled.				
Collection process (specified by type)	Collected separately	kg/m^2	1.60E+02	1.86E+02	3.84E+01
	Collected with mixed construction waste	kg/m^2	0.00E+00	0.00E+00	0.00E+00
Recovery (specified by type)	Reuse	kg/m^2	2.08E+01	2.41E+01	4.99E+00
	Recycling	kg/m^2	0.00E+00	0.00E+00	0.00E+00
	Incineration	kg/m^2	0.00E+00	0.00E+00	0.00E+00
Disposal (specified by type)	Landfill	kg/m^2	1.39E+02	1.61E+02	3.34E+01

4.8 D Benefits Beyond the System Boundary

Module D includes all benefits and loads beyond the system boundary. As per the PCR, 12% of the product mass in the functional unit is reused in the form of bulk aggregate to offset virgin sand or concrete material in the next product lifetime.

Table 4.11 – Module D Inventory

	Unit	Clay Brick & Structural Clay Tile	Clay Brick Paver	Thin Brick
Amount of gravel aggregate avoided due to reuse of product after collection	kg/m^2	15.24	22.27	3.19

4.9 EPD Generator Parameters

All Pacific Clay clay brick assemblies are represented by one EPD Generator and LCA parameterized model, due to similarities in product types. The parameters are described in detail in Appendix D. Table 4.12 below details the EPD generator parameter set for the clay brick assembly products.

Table 4.12 – Clay Brick Assemblies EPD Generator Parameters

Parameter	Unit	Clay Brick & Structural Clay Tile	Clay Brick Paver	Thin Brick
Mining	-	1.00E+00	1.00E+00	1.00E+00
Thin Brick Factor	-	5.58E+00	5.58E+00	5.58E+00
A1_Clay	kg/kg	1.26E+00	1.26E+00	7.02E+00
A1_Grog	kg/kg	3.22E-02	3.22E-02	1.80E-01
A1_Pigments	kg/kg	4.91E-03	4.91E-03	2.74E-02
A1_Body_additives	kg/kg	3.44E-03	3.44E-03	1.92E-02
A1_Sand	kg/kg	0.00E+00	0.00E+00	0.00E+00
A2_Transp_Rail	kgkm/kg	0.00E+00	0.00E+00	0.00E+00
A2_Transp_Truck	kgkm/kg	2.15E+01	2.15E+01	1.20E+02
A3_Electricity_Grid	kWh/kg	9.29E-02	9.29E-02	5.18E-01
N/A (not a parameter)	kWh/kg	1.38E-03	1.38E-03	7.70E-03
A3_Electricity_SPSO	kWh/kg	0.00E+00	0.00E+00	0.00E+00
A3_Electricity_ERCT	kWh/kg	0.00E+00	0.00E+00	0.00E+00
A3_Electricity_RFCW	kWh/kg	0.00E+00	0.00E+00	0.00E+00
A3_Electricity_MROW	kWh/kg	0.00E+00	0.00E+00	0.00E+00
A3_Electricity_SRVC	kWh/kg	0.00E+00	0.00E+00	0.00E+00
A3_Electricity_SRSO	kWh/kg	0.00E+00	0.00E+00	0.00E+00
A3_Electricity_RFCE	kWh/kg	0.00E+00	0.00E+00	0.00E+00
A3_Electricity_CAMX	kWh/kg	9.29E-02	9.29E-02	5.18E-01
A3_Electricity_NWPP	kWh/kg	0.00E+00	0.00E+00	0.00E+00
A3_Electricity_Poland	kWh/kg	0.00E+00	0.00E+00	0.00E+00
A3_Electricity_NEWE	kWh/kg	0.00E+00	0.00E+00	0.00E+00
A3_Electricity_RMPA	kWh/kg	0.00E+00	0.00E+00	0.00E+00
A3_Electricity_SRMV	kWh/kg	0.00E+00	0.00E+00	0.00E+00
A3_Electricity_Solar	kWh/kg	0.00E+00	0.00E+00	0.00E+00
A3_Electricity_Wind	kWh/kg	0.00E+00	0.00E+00	0.00E+00
A3_Natural_Gas	kWh/kg	3.16E+00	3.16E+00	1.76E+01

Parameter	Unit	Clay Brick & Structural Clay Tile	Clay Brick Paver	Thin Brick
A3_Diesel	ft3/kg	2.73E-04	2.73E-04	1.53E-03
A3_Hard_coal	gal/kg	0.00E+00	0.00E+00	0.00E+00
A3_Gasoline	ton/kg	8.71E-06	8.71E-06	4.86E-05
A3_Propane	gal/kg	3.68E-04	3.68E-04	2.06E-03
A3_Methane_landfill	gal/kg	0.00E+00	0.00E+00	0.00E+00
A3_Sawdust	ft^3/kg	0.00E+00	0.00E+00	0.00E+00
A3_Transport	tons/kg	2.12E+01	2.12E+01	1.19E+02
A3_Hydrated_Lime	kgkm/kg	0.00E+00	0.00E+00	0.00E+00
A3_Limestone	kg/kg	0.00E+00	0.00E+00	0.00E+00
A3_Sodium_bicarbonate	kg/kg	0.00E+00	0.00E+00	0.00E+00
A3_White_mineral_oil	kg/kg	0.00E+00	0.00E+00	0.00E+00
A3_Tap_Water	kg/kg	1.79E-01	1.79E-01	1.00E+00
A3_Well_Water	kg/kg	0.00E+00	0.00E+00	0.00E+00
A3_Plastic_Pkg	kg/kg	2.46E-04	2.46E-04	1.37E-03
A3_Steel_Pkg	kg/kg	2.81E-06	2.81E-06	1.57E-05
A3_Paper_Pkg	kg/kg	1.60E-04	1.60E-04	8.93E-04
A3_Wood_Pkg	kg/kg	0.00E+00	0.00E+00	0.00E+00
A3_Pallets	ft3/kg	7.00E-04	7.00E-04	3.91E-03
A3_Nonhaz_Waste	ft3/kg	2.48E-03	2.48E-03	1.38E-02
A3_Haz_Waste	kg/kg	0.00E+00	0.00E+00	0.00E+00
A3_Wastewater	kg/kg	4.56E-02	4.56E-02	2.54E-01
A3_Carbon_dioxide	gal/kg	3.43E-02	3.43E-02	1.92E-01
A3_Carbon_monoxide	kg/kg	5.46E-05	5.46E-05	3.05E-04
A3_Chlorine	kg/kg	6.50E-07	6.50E-07	3.63E-06
A3_Hydrogen_chloride	kg/kg	8.50E-05	8.50E-05	4.75E-04
A3_Hydrogen_fluoride	kg/kg	1.85E-04	1.85E-04	1.03E-03
A3_Lead	kg/kg	1.63E-10	1.63E-10	9.09E-10
A3_Mercury	kg/kg	3.75E-09	3.75E-09	2.09E-08
A3_CH4	kg/kg	3.61E-06	3.61E-06	2.01E-05
A3_Nitrogen_dioxide	kg/kg	0.00E+00	0.00E+00	0.00E+00
A3_Nitrogen_oxides	kg/kg	1.30E-04	1.30E-04	7.24E-04
A3_particles_PM2_5	kg/kg	1.16E-05	1.16E-05	6.47E-05
A3_particles_PM10	kg/kg	2.32E-05	2.32E-05	1.29E-04
A3_Sulfur_dioxide	kg/kg	9.36E-07	9.36E-07	5.23E-06
A3_VOC_unspecified	kg/kg	1.03E-04	1.03E-04	5.75E-04

5.0 Clay Brick Assemblies Cradle-to-Grave LCA Results

This section describes the cradle-to-grave life cycle inventory of the clay brick assemblies and outlines the results of the LCA study. Primary manufacturing data were collected from surveys completed by personnel from each of the Pacific Clay manufacturing plants for the 2023 calendar production year. The participating manufacturing plants provided resource transportation mode and distance data to support the calculation of raw material transportation flows. The transportation LCI data from the USLCI database (kg-km basis) were used to develop the resource transportation LCI profile.

The results presented in this section are for the baseline products for each sub-category. For results of all products, refer to Appendix C: EPD and Scaling Factor Tables. While each line in the scaling factor tables represents a baseline product, the products covered within that evaluation do not differ by more than +/-10% in all environmental impact indicators.

5.1 Clay Brick & Structural Clay Tile Cradle-to-Grave Impacts

The following analysis details the cradle-to-grave impact assessment for clay brick & structural clay tile products manufactured by Pacific Clay. While the system boundary is cradle-to-grave, only life cycle stages and modules are shown that have non-zero values (Modules B1, B3-B7, C1, and C3 have impacts of zero in all indicators).

Table 5.1 – Clay Brick & Structural Clay Tile Cradle-to-Grave Impacts (per square meter)

Impact Category	Unit	A1. Raw Materials	A2. Raw Material Transportation	A3. Manufacturing	A4. Distribution	A5. Installation Brick Impacts	A5. Installation Mortar Impacts	B2. Maintenance	C2. Waste Transportation	C4. Final Disposal	D. Beyond the System
Global warming potential	kg CO_2-Eq.	1.69E+00	2.53E-01	3.68E+01	4.80E+00	2.42E+00	8.25E+00	0.00E+00	1.54E+00	2.38E+00	-6.89E-02
Depletion potential of the stratospheric ozone layer	kg CFC-11 Eq.	1.48E-08	9.58E-12	1.59E-08	1.82E-10	3.98E-09	3.72E-08	0.00E+00	6.45E-11	4.80E-08	-7.10E-10
Acidification potential for air emissions	kg SO_2-Eq.	1.09E-02	1.51E-03	3.35E-01	2.86E-02	2.05E-02	2.62E-02	0.00E+00	2.03E-02	1.32E-02	-4.18E-04
Freshwater eutrophication potential	kg P-Eq.	3.72E-04	2.86E-07	3.85E-04	5.42E-06	1.26E-04	8.50E-04	0.00E+00	1.92E-06	1.40E-04	-1.27E-05
Marine eutrophication potential	kg N-Eq.	1.12E-03	3.45E-04	1.14E-02	6.53E-03	1.43E-03	4.46E-03	0.00E+00	5.38E-03	3.08E-03	-8.07E-05
Smog formation potential	kg O_3-Eq.	1.25E-01	4.14E-02	1.43E+00	7.84E-01	1.64E-01	5.02E-01	0.00E+00	5.22E-01	3.64E-01	-9.01E-03

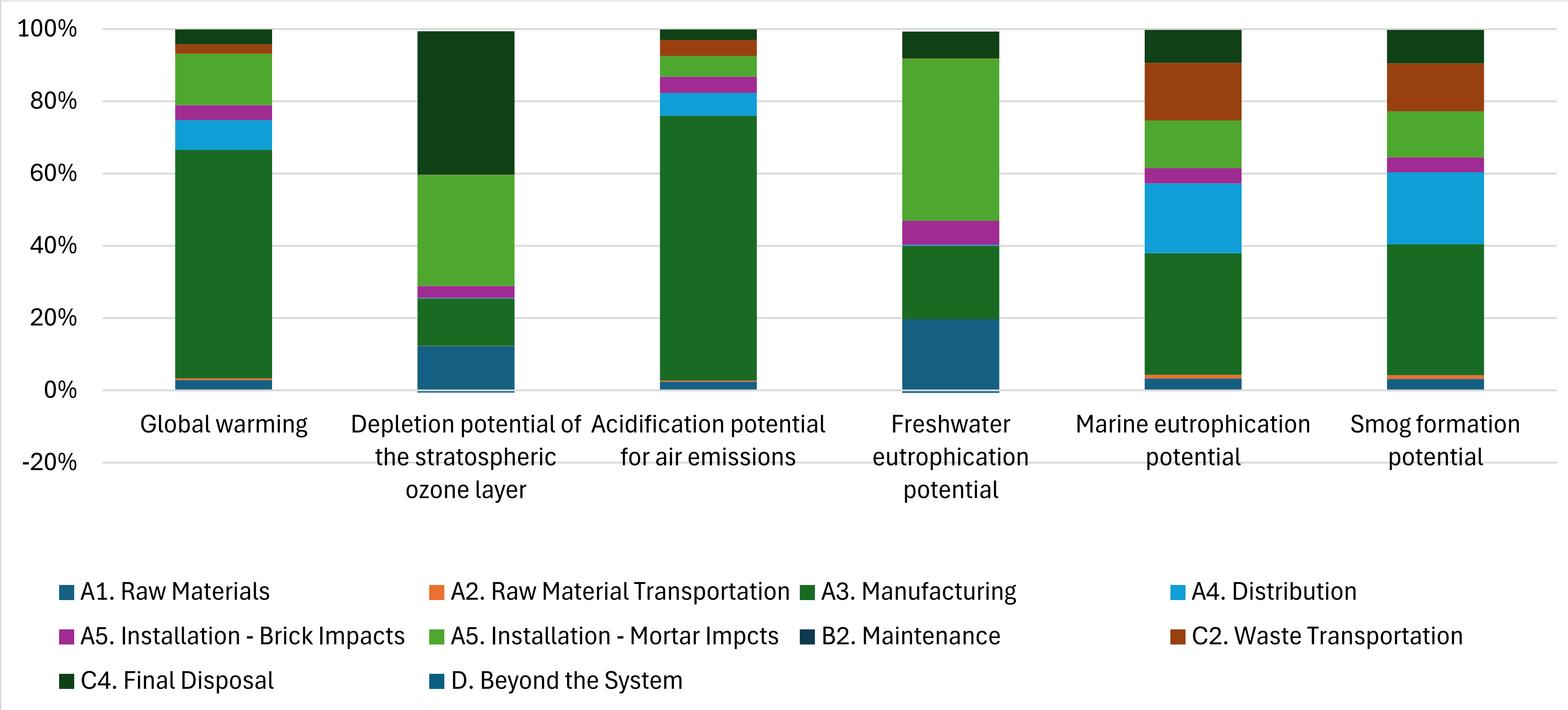


Figure 5.1 – Clay Brick & Structural Clay Tile Cradle-to-Grave Impacts (per square meter)

The highest contributor to all impacts is the A3 manufacturing stage. In this stage, the largest amount of energy is required due to the firing process. In most stages of a brick's life, relatively minimal energy is required; for instance, extracting the clay material from the ground is efficient. The next highest contributor is the A5 installation stage. The mortar required in this stage has high upstream processing costs, which drives its environmental impacts. Due to the high weight of the brick functional unit, A4 distribution transportation is proportionally high as well.

5.2 Clay Brick Paver Cradle-to-Grave Impacts

The following analysis details the cradle-to-grave impact assessment for clay brick paver products manufactured by Pacific Clay. While the system boundary is cradle-to-grave, only life cycle stages and modules are shown that have non-zero values (Modules B1, B3-B7, C1, and C3 have impacts of zero in all indicators).

Table 5.2 – Clay Brick Paver Cradle-to-Grave Impacts (per square meter)

Impact Category	Unit	A1. Raw Materials	A2. Raw Material Transportation	A3. Manufacturing	A4. Distribution	A5. Installation Brick Impacts	A5. Installation Mortar Impacts	B2. Maintenance	C2. Waste Transportation	C4. Final Disposal	D. Beyond the System
Global warming potential	kg CO_2-Eq.	2.47E+00	3.70E-01	5.38E+01	7.01E+00	3.54E+00	0.00E+00	1.63E+00	2.25E+00	3.48E+00	-1.01E-01
Depletion potential of the stratospheric ozone layer	kg CFC-11 Eq.	2.17E-08	1.40E-11	2.33E-08	2.65E-10	5.81E-09	0.00E+00	1.54E-07	9.43E-11	7.02E-08	-1.04E-09
Acidification potential for air emissions	kg SO_2-Eq.	1.59E-02	2.21E-03	4.89E-01	4.19E-02	3.00E-02	0.00E+00	1.07E-02	2.97E-02	1.93E-02	-6.11E-04
Freshwater eutrophication potential	kg P-Eq.	5.44E-04	4.18E-07	5.62E-04	7.92E-06	1.84E-04	0.00E+00	2.94E-04	2.81E-06	2.05E-04	-1.85E-05
Marine eutrophication potential	kg N-Eq.	1.63E-03	5.04E-04	1.66E-02	9.54E-03	2.09E-03	0.00E+00	1.89E-03	7.87E-03	4.51E-03	-1.18E-04
Smog formation potential	kg O_3-Eq.	1.82E-01	6.05E-02	2.08E+00	1.15E+00	2.40E-01	0.00E+00	2.36E-01	7.63E-01	5.32E-01	-1.32E-02

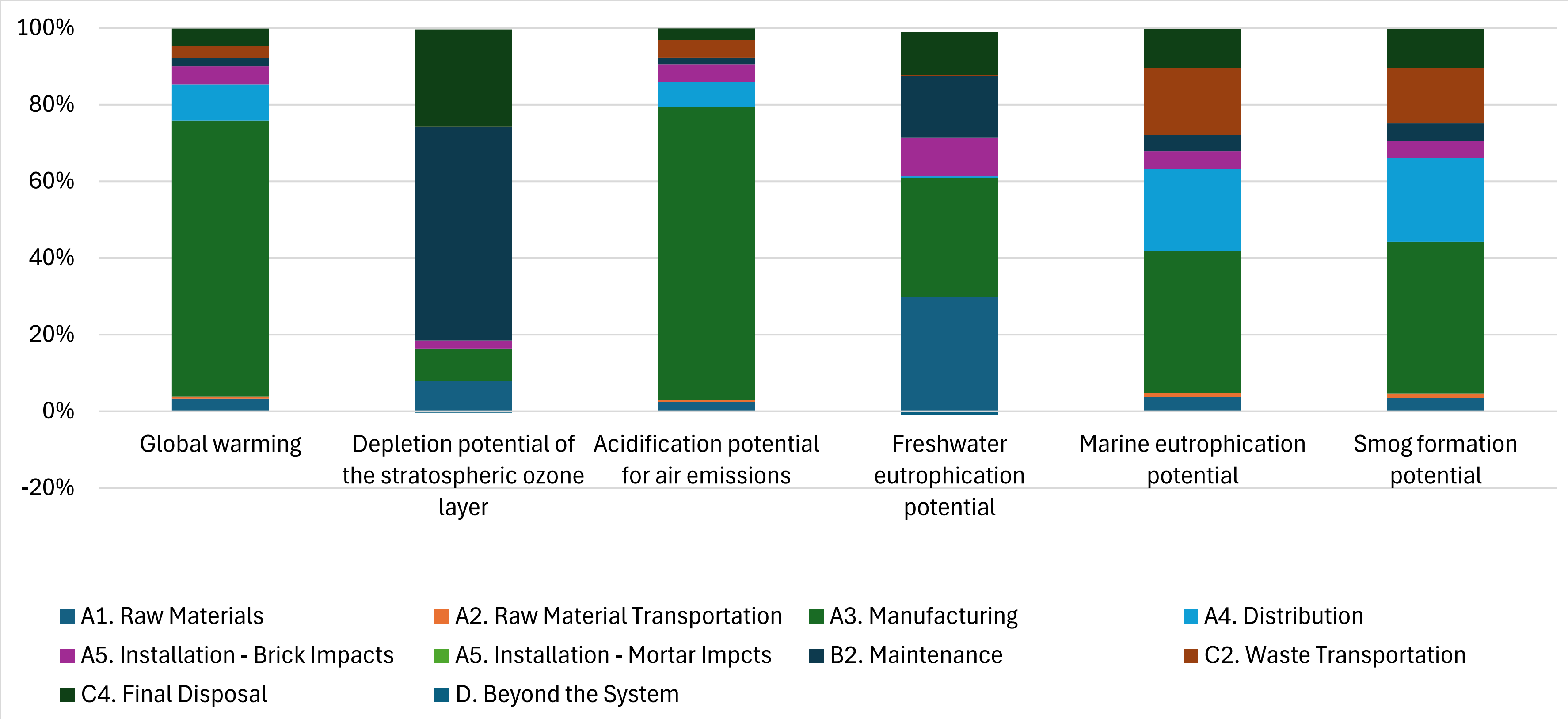


Figure 5.2 – Clay Brick Paver Cradle-to-Grave Impacts (per square meter)

The highest contributor to all impacts is the A3 manufacturing stage. In this stage, the largest amount of energy is required due to the firing process. In most stages of a brick's life, relatively minimal energy is required; for instance, extracting the clay material from the ground is efficient. The next highest contributor is the A4 distribution due to the heavy nature of the transportation. The next highest contributor is the A1 raw materials stage. The upstream processing of the raw material additives and pigments drive the environmental impacts of A1. Due to the high weight of the brick functional unit, A4 distribution transportation is proportionally high as well.

5.3 Thin Brick Cradle-to-Grave Impacts

The following analysis details the cradle-to-grave impact assessment for thin brick products manufactured by Pacific Clay. While the system boundary is cradle-to-grave, only life cycle stages and modules are shown that have non-zero values (Modules B1, B3-B7, C1, and C3 have impacts of zero in all indicators).

Table 5.3 – Thin Brick Cradle-to-Grave Impacts (per square meter)

Impact Category	Unit	A1. Raw Materials	A2. Raw Material Transportation	A3. Manufacturing	A4. Distribution	A5. Installation Brick Impacts	A5. Installation Mortar Impacts	B2. Maintenance	C2. Waste Transportation	C4. Final Disposal	D. Beyond the System
Global warming potential	kg CO_2-Eq.	1.97E+00	2.96E-01	4.30E+01	1.00E+00	5.07E-01	2.98E+00	0.00E+00	3.22E-01	4.98E-01	-1.44E-02
Depletion potential of the stratospheric ozone layer	kg CFC-11 Eq.	1.73E-08	1.12E-11	1.86E-08	3.80E-11	8.32E-10	1.34E-08	0.00E+00	1.35E-11	1.00E-08	-1.49E-10
Acidification potential for air emissions	kg SO_2-Eq.	1.27E-02	1.77E-03	3.91E-01	6.00E-03	4.29E-03	9.44E-03	0.00E+00	4.26E-03	2.77E-03	-8.76E-05
Freshwater eutrophication potential	kg P-Eq.	4.35E-04	3.34E-07	4.50E-04	1.13E-06	2.63E-05	3.07E-04	0.00E+00	4.03E-07	2.93E-05	-2.65E-06
Marine eutrophication potential	kg N-Eq.	1.31E-03	4.03E-04	1.33E-02	1.37E-03	2.99E-04	1.61E-03	0.00E+00	1.13E-03	6.46E-04	-1.69E-05
Smog formation potential	kg O_3-Eq.	1.46E-01	4.84E-02	1.67E+00	1.64E-01	3.43E-02	1.81E-01	0.00E+00	1.09E-01	7.62E-02	-1.89E-03

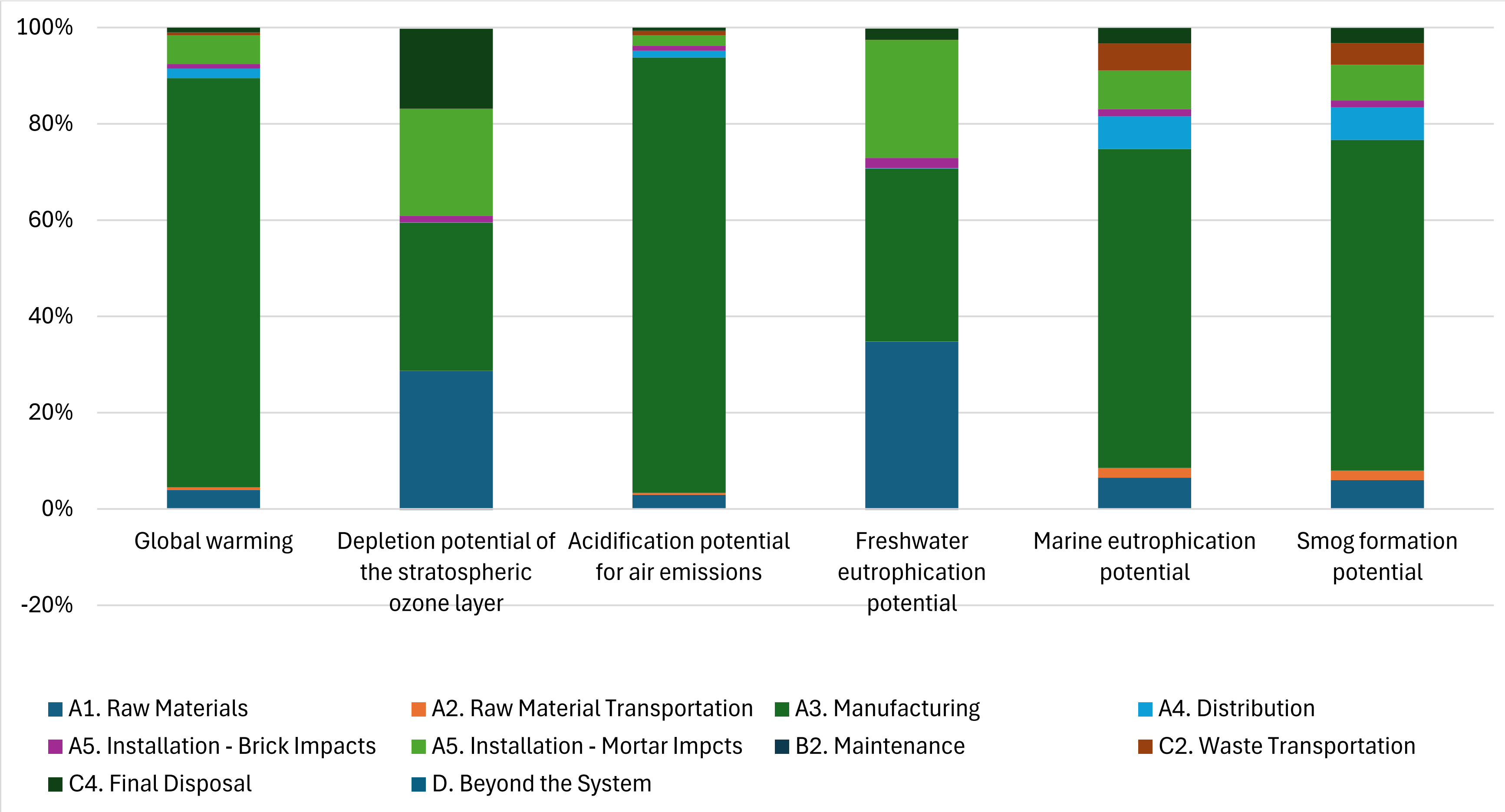


Figure 5.3 – Thin Brick Cradle-to-Grave Impacts (per square meter)

Thin brick is different from the full-sized bricks because they have a much lower weight per functional unit. This reduces the impacts per functional unit of all impacts downstream of the manufacturing. However, as mentioned above, the A1-A3 stages are scaled up due to the sawing of the full brick. Therefore, the relative impact of the A1-A3 stages are higher than for the other product types. Additionally, the mortar required for A5 installation has considerable impacts as well.

6.0 Sensitivity Analysis

Sensitivity analysis is used in LCA to evaluate the impact that assumptions and modeling decisions have on the product's environmental impacts. This LCA was conducted in alignment with the BIA Industry-Average LCA report. As such, all relevant sensitivity analyses to refine the system boundary were conducted in that report and can be seen there.

7.0 Additional Product Comparisons

While knowing the environmental impacts of clay brick assemblies are valuable in itself, some perspective can also be useful to answer the question of how these impacts compare to the overall brick industry. BIA commissioned an industry average LCA in 2025 to evaluate the industry impacts and serve as the basis for the PCR. In order to evaluate how the Pacific Clay stacks up against the industry, this section will compare the impacts from the industry average study to this study.

In alignment with the ISO standards, this comparison is not to be used for external marketing claims of environmental superiority and is only intended to inform Pacific Clay how their current product impacts compare to the overall brick industry. Table 7.1 and Figure 7.1 detail the results of the comparison.

Table 7.1 – Cradle-to-Grave Impact Comparison (per square meter)

Impact Category	Unit	BIA Clay Brick & Structural Clay Tile	Pacific Clay Clay Brick & Structural Clay Tile	BIA Clay Brick Paver	Pacific Clay Clay Brick Paver	BIA Thin Brick	Pacific Clay Thin Brick
Global warming potential	kg CO_2-Eq.	4.97E+01	5.81E+01	4.04E+01	7.44E+01	3.41E+01	5.06E+01
Depletion potential of the stratospheric ozone layer	kg CFC-11 Eq.	1.49E-07	1.20E-07	2.58E-07	2.74E-07	7.99E-08	6.02E-08
Acidification potential for air emissions	kg SO_2-Eq.	4.70E-01	4.55E-01	4.25E-01	6.38E-01	3.64E-01	4.32E-01
Freshwater eutrophication potential	kg P-Eq.	2.10E-03	1.87E-03	1.46E-03	1.78E-03	1.30E-03	1.25E-03
Marine eutrophication potential	kg N-Eq.	4.27E-02	3.36E-02	3.77E-02	4.45E-02	2.57E-02	2.00E-02
Smog formation potential	kg O_3-Eq.	4.91E+00	3.92E+00	4.36E+00	5.23E+00	3.00E+00	2.42E+00

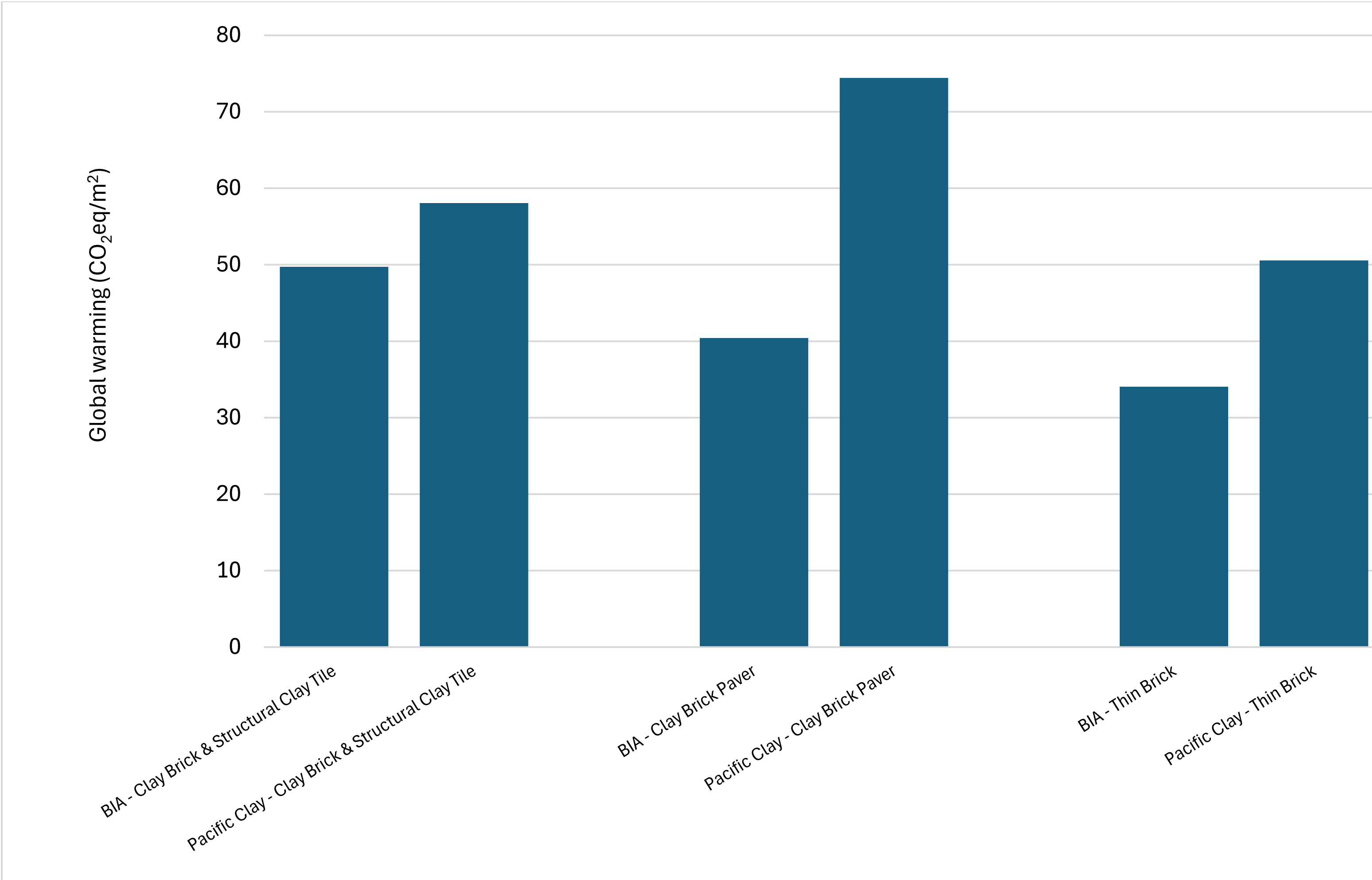


Figure 7.1 – Cradle-to-Grave Impact Comparison (per square meter)

The results presented here are per square meter of brick for the "cradle-to-grave" scope. This means that the amount of brick product is consistent over all products. Additionally, the thin brick measures one square meter of brick product, not fired brick, so, due to the sawing, the thin brick impacts are much higher than the other brick products in this study. The Pacific Clay results are more than the BIA results due to the manufacturing impacts.

8.0 Interpretation

8.1 Conclusions

Based on the results from the life cycle assessment, the life cycle impacts of each clay brick assembly type are strongly driven by the manufacturing process. This impact is specifically influenced by the natural gas used in the kiln, electricity used in the process, and process emissions from the raw materials chemical reaction. However, the most significant improvements would be found in reductions to the natural gas consumption in the kiln.

Pacific Clay has direct control over the modes of transportation for raw materials and final products, as well as the manufacturing process. Any opportunities to reduce energy consumption (by implementing "green fleets") in these areas will have a direct reduction in environmental impacts. It will also provide cost savings and potential competitive advantages to Pacific Clay.

The impact of raw materials is minor in most impact categories due to the majority of the mass composition being clay and shale materials which only require diesel consumption to extract. There are some added impacts from pigments and body additives used to give clay brick assemblies the aesthetic and functional performance desired. Any R&D efforts for the material compositions should be focused on these materials to ensure they are addressing the most impactful components. It is recommended that the PCR developed for clay brick assemblies requires the inclusions of pigments in the LCA studies.

The process controls that have been implemented by the BIA member companies are helping to reduce the total environmental impact of clay brick assemblies. Further improvements toward reducing the total energy required for the manufacturing process will prove to have significant effects in reducing total environmental impacts. However, it should also be noted that thin brick allocation and variability in process techniques can greatly influence the product's impacts, and should be specific to the manufacturing operation of interest.

8.2 Limitations

This LCA is intended for internal use only and is pending a formal peer review in February 2026 by Jack Geibig, Ecoform, as is required by ISO 14040 Standards, for external release of results. The study was conducted following appropriate ISO standards and best practices but is intended for internal use to assist Pacific Clay with understanding the life cycle impacts of their products.

All data for the operation of the Pacific Clay plants, as well as transportation distances and modes, was collected directly from each Pacific Clay facility. Efforts were made to check the data for internal consistency and to verify data with plant personnel and Terry Schimmel, a brick industry expert with 30+ years of experience working in clay brick assembly facilities.

The findings in this research are limited by the inherent uncertainty of creating a representative model through LCA. Many assumptions were made in modeling the product system with representative processes and datasets, as outlined in Section 1.6. The authors addressed the uncertainty in modeling decisions by conducting a mass balance and sensitivity analysis as the LCI model was being constructed (data verification/validation relative to cut-off criteria and study goals), as seen in the BIA industry average report.

One of the most significant limitations of the study is the allocation method employed for thin brick products. Thin brick inventory data had to be scaled to account for the waste material that is generated from sawing full size bricks; however, sub-metered data, specific to the production of thin brick, was not available by the manufacturing sites.

An additional limitation to the study is the assumption of which pigments were included in the study. Since actual pigment data was not commonly tracked by Pacific Clay, this study had to rely on a large supplier for common pigment usage. The sensitivity analysis shown in the BIA industry average LCA report proved this to not be a major impact changing factor, but better tracking and measuring would support more accurate analysis in the future.

While quality control was undertaken at each step in building the LCI and conducting the LCIA, uncertainty is still present in the results since the data evaluated represents only one year of manufacturing information. Detailed evaluation of multiple time periods would reduce the uncertainty. Some level of uncertainty is inherent in conducting LCA and decision making must reflect this fact.

8.3 Recommendations

Sustainable Solutions Corporation is recommending the results of this LCA be used to move forward with the publication of the Pacific Clay clay brick assembly data at this time through an EPD which will be developed according to the PCR. This information can prepare Pacific Clay for future sustainable supply chain requirements and can form the basis of marketing literature focused on environmental benefits. This LCA will also assist Pacific Clay with modeling and evaluating any green product claims by competitor industries.

Pacific Clay should use the clay brick assembly life cycle assessment for evaluating alternate raw materials, such as pigments, as well as source locations, recycled content, and alternate transportation modes as part of a sustainable product development process.

The development of scrap reduction methods at the Pacific Clay facility should continue to be explored to reduce costs and environmental impacts. Opportunities to implement direct extrusion manufacturing processes to thin brick production will greatly reduce waste material. Additionally, identifying alternative materials for pigments and body additives should be explored to address the primary raw material impact driving components. These investigations may lead to a reduction in the environmental impacts of the final product.

Appendix A: Process Flow Diagram

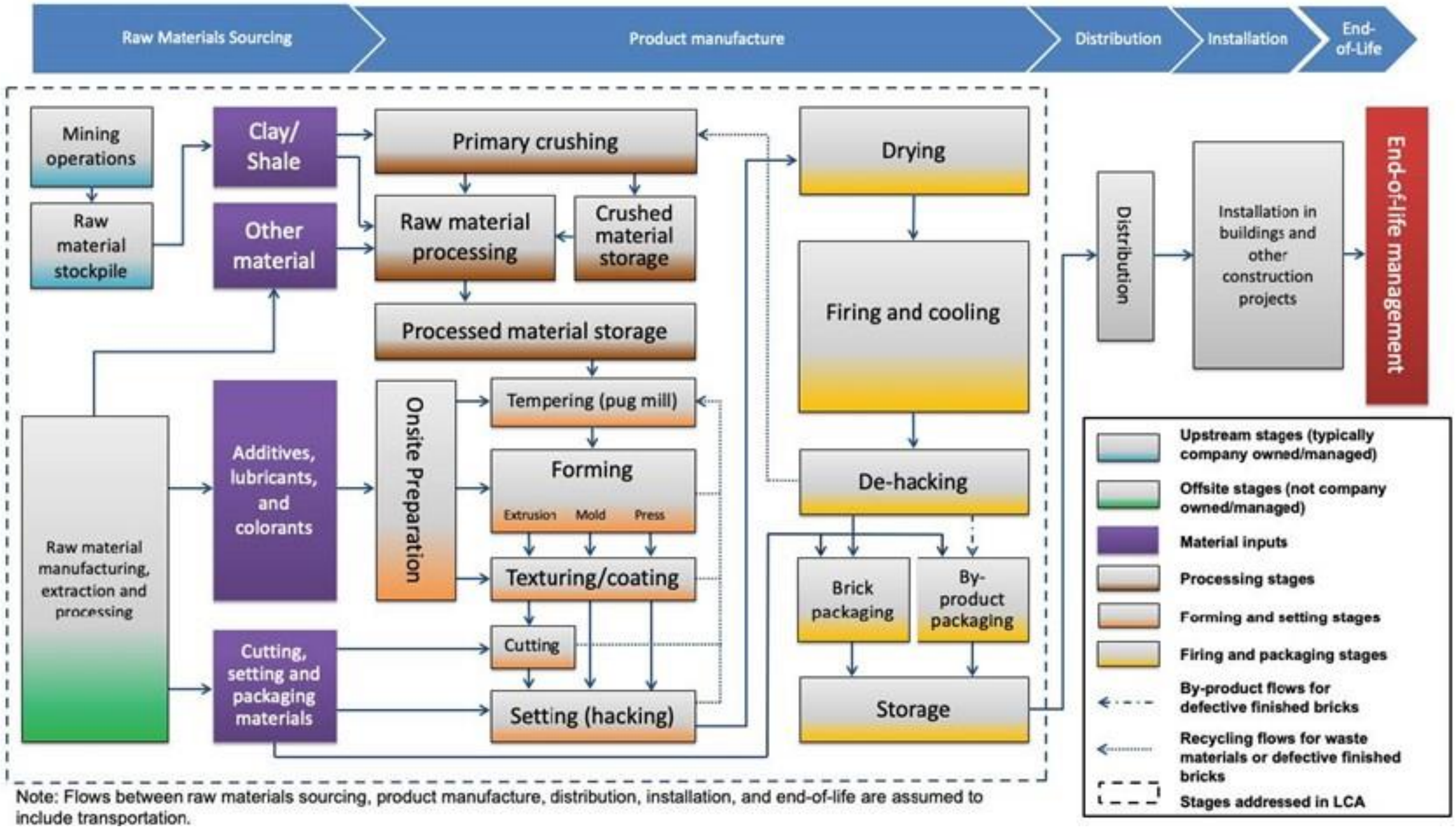


Figure A. 1 – BIA Process Flow Diagram for Clay Brick Assemblies

Appendix B: Data Sources and Data Quality

Table B. 1 – Clay Brick Assembly Data Quality Analysis

Raw Materials	Database(s)	Source	Temporal Information	Regional Coverage	Technology Coverage	Data Type	Data Quality
Mined Clay and Shale	Clay	See technology coverage.	2023	United States	A dataset was generated to evaluate the amount of diesel used to mine clay and shale using primary data. The value stated here is averaged from similar mining processes. **0.765 liters of diesel per short ton of wet material mined**. Also include **1 short ton of "Inputs from Nature - Clay"**	Primary	Good
	Diesel, combusted in industrial equipment/US	USLCI	2013	United States	This dataset describes diesel combustion in average industrial boiler.	Secondary	Fine
Grog	Rock crushing {RoW}| rock crushing | Cut-off, U	ecoinvent 3	2023	Rest of World	This dataset Includes the machine, spares and wears, lubricating oil, and the transportation of the new parts to the assembly plant as well as transportation of the crusher to the operational sites. Electricity consumption and dust emissions are not included.	Secondary	Good
Manganese dioxide/Manganese (III) oxide [PROXY]	Manganese dioxide {GLO}| market for manganese dioxide | Cut-off, U	ecoinvent 3	2023	Global	This activity starts at the gate of the activities that produce 'manganese dioxide', within the geography of Global. This activity ends with the supply of 'manganese dioxide', to the consumers of this product. Transport is included. Product losses during transportation are assumed negligible and are therefore not included.	Secondary	Good
Iron Chromite [PROXY]	Chromite ore concentrate {RoW}| chromite ore concentrate production | Cut-off, U	ecoinvent 3	2023	Global	This activity starts with mining process starting from chromite ore, in ground. The activity ends with the gravity concentration of the material, at the beneficiation facility. The dataset includes the crushing, grounding and screening of mined ore, the production infrastructure for mining and beneficiation, and the disposal of overburden and tailings.	Secondary	Good
Body Additives	Barium carbonate {GLO}| market for barium carbonate | Cut-off, U	ecoinvent 3	2023	Global	This activity starts at the gate of the activities that produce barium carbonate within the geography of this dataset, with the product ready for transportation. This activity ends with the supply of 1 kg of barium carbonate to the consumers of this product. Transport is included. Product losses during transportation are assumed negligible and are therefore not included.	Secondary	Good
Sand	Sand {RoW}| market for sand | Cut-off, U	ecoinvent 3	2023	Rest of World	This activity starts at the gate of the activities that produce 'sand', within the geography of Global. This activity ends with the supply of 'sand', to the consumers of this product. Transport is included. Product losses during transportation are assumed negligible and are therefore not included.	Secondary	Good

Raw Material Transportation	Database(s)	Source	Temporal Information	Regional Coverage	Technology Coverage	Data Type	Data Quality
Rail	Transport, train, diesel powered/US	USLCI	2008	United States	This dataset includes combustions of diesel in a locomotive.	Secondary	Fine
Truck	Transport, combination truck, average fuel mix/US	USLCI	2008	United States	This dataset includes vehicle operation and mixing process for combination truck, assuming 100% diesel and 0% gasoline.	Secondary	Fine
Packaging Materials	**Database(s)**	**Source**	**Temporal Information**	**Regional Coverage**	**Technology Coverage**	**Data Type**	**Data Quality**
Plastic Straps	Polypropylene resin, at plant/RNA	USLCI	2013	United States	Includes material and energy requirements and environmental emissions for one kilogram of polypropylene resin production. Polymerization of propylene using Ziegler-Natta catalysts via a combination of the liquid monomer and gas phase processes	Secondary	Fine
Metal Straps	Cold rolled sheet, steel, at plant/RNA	USLCI	2014	United States	Includes extraction of limestone, lime production, exploration, mining and processing of iron ore and coal, transportation to mill by ship, rail and truck (burnt lime, dolomite, iron ore and coal), primary processes (sinter plant, coke ovens, stoves, boilers, blast furnace and BOF), casting line, hot strip mill and cold mill complex.	Secondary	Fine
Paper Dividers	Paper, freesheet, uncoated, average production, at mill/kg/RNA	USLCI	2014	United States	The unit process includes paper production from wood and drying. Purchased energy is included, but upstream flows associated with its generation are excluded. Flows associated with transportation of inputs from the technosphere are included. Product transportation is excluded. Air emissions from process sources are included. Emissions related to the combustion of fuels are excluded but can be found in other datasets.	Secondary	Fine
Wooden Dividers Pallets	Pulpwood, hardwood, average, at forest road, NE-NC/m3/RNA	USLCI	2010	United States	Average of the Forestry and Logging processes Average technology. Some data extrapolated from similar processes.	Secondary	Fine
Water	**Database(s)**	**Source**	**Temporal Information**	**Regional Coverage**	**Technology Coverage**	**Data Type**	**Data Quality**
Tap Water	Tap water {RoW}| market for tap water | Cut-off, U	ecoinvent 3	2023	Rest of World	This dataset describes average tap water available, at user, on a global level. Since tap water is mainly produced and distributed at a regional level, regional markets should be preferred, when relevant.	Secondary	Good
Well Water	Water (well water)	N/A	N/A	N/A	Input from nature.	Secondary	Good
Manufacturing Transportation	**Database(s)**	**Source**	**Temporal Information**	**Regional Coverage**	**Technology Coverage**	**Data Type**	**Data Quality**
Truck	Transport, combination truck, average fuel mix/US	USLCI	2008	United States	This dataset includes vehicle operation and mixing process for combination truck, assuming 100% diesel and 0% gasoline.	Secondary	Fine

Electricity	Database(s)	Source	Temporal Information	Regional Coverage	Technology Coverage	Data Type	Data Quality
Electricity, SPSO eGrid	Electricity, at eGrid, SPSO, 2023/RNA U	USLCI	2023	United States	Representative of year 2023 mix of fuels used for utility electricity generation in the SPSO region. Fuels include biomass, coal, petroleum, natural gas, hydroelectric, wind and other energy sources. SSC modified this process to reflect 2023 grid mix data from the EPA.	Secondary	Good
Electricity, ERCT eGrid	Electricity, at eGrid, ERCT, 2023/RNA U	USLCI	2023	United States	Representative of year 2023 mix of fuels used for utility electricity generation in the ERCT region. Fuels include biomass, coal, petroleum, natural gas, hydroelectric, wind and other energy sources. SSC modified this process to reflect 2023 grid mix data from the EPA.	Secondary	Good
Electricity, RFCW eGrid	Electricity, at eGrid, RFCW, 2023/RNA U	USLCI	2023	United States	Representative of year 2023 mix of fuels used for utility electricity generation in the RFCW region. Fuels include biomass, coal, petroleum, natural gas, hydroelectric, wind and other energy sources. SSC modified this process to reflect 2023 grid mix data from the EPA.	Secondary	Good
Electricity, MROW eGrid	Electricity, at eGrid, MROW, 2023/RNA U	USLCI	2023	United States	Representative of year 2023 mix of fuels used for utility electricity generation in the MROW region. Fuels include biomass, coal, petroleum, natural gas, hydroelectric, wind and other energy sources. SSC modified this process to reflect 2023 grid mix data from the EPA.	Secondary	Good
Electricity, SRVC eGrid	Electricity, at eGrid, SRVC, 2023/RNA U	USLCI	2023	United States	Representative of year 2023 mix of fuels used for utility electricity generation in the SRVC region. Fuels include biomass, coal, petroleum, natural gas, hydroelectric, wind and other energy sources. SSC modified this process to reflect 2023 grid mix data from the EPA.	Secondary	Good
Electricity, SRSO eGrid	Electricity, at eGrid, SRSO, 2023/RNA U	USLCI	2023	United States	Representative of year 2023 mix of fuels used for utility electricity generation in the SRSO region. Fuels include biomass, coal, petroleum, natural gas, hydroelectric, wind and other energy sources. SSC modified this process to reflect 2023 grid mix data from the EPA.	Secondary	Good
Electricity, RFCE eGrid	Electricity, at eGrid, RFCE, 2023/RNA U	USLCI	2023	United States	Representative of year 2023 mix of fuels used for utility electricity generation in the RFCE region. Fuels include biomass, coal, petroleum, natural gas, hydroelectric, wind and other energy sources. SSC modified this process to reflect 2023 grid mix data from the EPA.	Secondary	Good
Electricity, CAMX eGrid	Electricity, at eGrid, CAMX, 2023/RNA U	USLCI	2023	United States	Representative of year 2023 mix of fuels used for utility electricity generation in the CAMX region. Fuels include biomass, coal, petroleum, natural gas, hydroelectric, wind and other energy sources. SSC modified this process to reflect 2023 grid mix data from the EPA.	Secondary	Good

Electricity	Database(s)	Source	Temporal Information	Regional Coverage	Technology Coverage	Data Type	Data Quality
Electricity, NWPP eGrid	Electricity, at eGrid, NWPP, 2023/RNA U	USLCI	2023	United States	Representative of year 2023 mix of fuels used for utility electricity generation in the NWPP region. Fuels include biomass, coal, petroleum, natural gas, hydroelectric, wind and other energy sources. SSC modified this process to reflect 2023 grid mix data from the EPA.	Secondary	Good
Electricity, NENW eGrid	Electricity, at eGrid, NEWE, 2023/RNA U	USLCI	2023	United States	Representative of year 2023 mix of fuels used for utility electricity generation in the NW region. Fuels include biomass, coal, petroleum, natural gas, hydroelectric, wind and other energy sources. SSC modified this process to reflect 2023 grid mix data from the EPA.	Secondary	Good
Electricity, RMPA eGrid	Electricity, at eGrid, RMPA, 2023/RNA U	USLCI	2023	United States	Representative of year 2023 mix of fuels used for utility electricity generation in the RMPA region. Fuels include biomass, coal, petroleum, natural gas, hydroelectric, wind and other energy sources.	Secondary	Good
Electricity, Low Voltage	Electricity, low voltage {RoW}| electricity production, photovoltaic, 3kWp flat-roof installation, multi-Si | Cut-off, U	ecoinvent 3	2023	Rest of World	From the PV module installed and ready to be used. This activity ends with low voltage electricity produced with the 3 kWp module, assuming an average yield.	Secondary	Good
Electricity, Medium Voltage	Electricity, medium voltage {PL}| market for electricity, medium voltage | Cut-off, U	ecoinvent 3	2023	Poland	Average technology used to transmit and distribute electricity. Includes underground and overhead lines, as well as air-, vacuum- and SF6-insulated high-to-medium voltage switching stations. Electricity production according to related technology datasets.	Secondary	Good
Electricity, High Voltage	Electricity, high voltage {US-TRE}| electricity production, wind, 1-3MW turbine, onshore | Cut-off, U	ecoinvent 3	2023	United States - Texas	From operation of the wind power plant to high voltage electricity at the plant. According to (European Communities 2001), electricity produced with wind turbines in a wind power plant is connected to medium voltage or high voltage systems, depending on the size of the windfarm. Normally, each wind turbine contains a transformer from low voltage to medium voltage. The network connection additionally transforms the electricity to high voltage electricity. It is assumed here, that there are no stand-alone grid-connected small wind turbines and that all electricity is connected to the network in form of high voltage electricity.	Secondary	Good

Fuels	Database(s)	Source	Temporal Information	Regional Coverage	Technology Coverage	Data Type	Data Quality
Hard Coal	Bituminous coal, combusted in industrial boiler/US	USLCI	2008	United States	Surface mining is used to extract 58 percent of the U.S. supply of coal, while underground mining extracts 42 percent	Secondary	Fine
Gasoline	Gasoline, combusted in equipment/US	USLCI	2008	United States	Gasoline combustion in equipment such as mobile refrigeration units, generators, pumps, and portable well-drilling equipment.	Secondary	Fine

Fuels	Database(s)	Source	Temporal Information	Regional Coverage	Technology Coverage	Data Type	Data Quality
Propane	Liquefied petroleum gas, combusted in industrial boiler/US	USLCI	2008	United States	LPG combustion in average industrial boiler.	Secondary	Fine
Landfill Methane	Heat, central or small-scale, biomethane {RoW}| heat production, biomethane, at boiler condensing modulating <100kW | Cut-off, U	ecoinvent 3	2019	Rest of World	The module includes fuel input from low pressure (CH) network, infrastructure (boiler), emissions to air and water, and electricity needed for operation.	Secondary	Good
Sawdust	Combustion, dry wood residue, AP-42/MJ/RNA	USLCI	2011	United States and Canada	Process includes emissions from wood combustion with material input considered as a waste stream.	Secondary	Fine
Natural Gas	Natural gas, combusted in industrial boiler/US	USLCI	2022	United States	This dataset describes natural gas combustion in average industrial boiler.	Secondary	Good
Diesel	Diesel, combusted in industrial equipment/US	USLCI	2013	United States	This dataset describes diesel combustion in average industrial boiler.	Secondary	Fine

Support Materials	Database(s)	Source	Temporal Information	Regional Coverage	Technology Coverage	Data Type	Data Quality
Hydrated Lime	Lime, hydrated, packed {RoW}| market for lime, hydrated, packed | Cut-off, U	ecoinvent 3	2021	Rest of World	This activity starts at the gate of the activities that produce 'lime, hydrated, packed', within the geography of Global. This activity ends with the supply of 'lime, hydrated, packed', to the consumers of this product. Transport is included. Product losses during transportation are assumed negligible and are therefore not included.	Secondary	Good
Limestone	Limestone, at mine/US	USLCI	2015	United States	Limestone mining is quarried from open pits by blasting, followed by mechanical crushing and screening.	Secondary	Fine
Sodium Bicarbonate	Sodium bicarbonate {RoW}| market for sodium bicarbonate | Cut-off, U	ecoinvent 3	2021	Rest of World	Activity starts at factory gate, with the finished product ready for transport. The activity includes the transport of the products to the consumer.	Secondary	Good
White Mineral Oil	White mineral oil, at plant/RNA	USLCI	2011	United States	Includes material and energy requirements and environmental emissions for one kilogram of white mineral oil.	Secondary	Fine

Emissions	Database(s)	Source	Temporal Information	Regional Coverage	Technology Coverage	Data Type	Data Quality
Carbon dioxide	Carbon dioxide	N/A	N/A	N/A	Emissions to air.	Secondary	Good

Emissions	Database(s)	Source	Temporal Information	Regional Coverage	Technology Coverage	Data Type	Data Quality
Carbon monoxide	Carbon monoxide	N/A	N/A	N/A	Emissions to air.	Secondary	Good
Chlorine	Chlorine	N/A	N/A	N/A	Emissions to air.	Secondary	Good
Hydrogen chloride	Hydrogen chloride	N/A	N/A	N/A	Emissions to air.	Secondary	Good
Hydrogen fluoride	Hydrogen fluoride	N/A	N/A	N/A	Emissions to air.	Secondary	Good
Lead	Lead	N/A	N/A	N/A	Emissions to air.	Secondary	Good
Mercury	Mercury	N/A	N/A	N/A	Emissions to air.	Secondary	Good
Methane	Methane	N/A	N/A	N/A	Emissions to air.	Secondary	Good
Nitrogen dioxide (NO2)	Nitrogen dioxide	N/A	N/A	N/A	Emissions to air.	Secondary	Good
Nitrous oxide (N2O)	Nitrous oxide	N/A	N/A	N/A	Emissions to air.	Secondary	Good
PM2.5	Particles (PM2.5)	N/A	N/A	N/A	Emissions to air.	Secondary	Good
PM10	Particles (PM10)	N/A	N/A	N/A	Emissions to air.	Secondary	Good
Sulfur dioxide	Sulfur dioxide	N/A	N/A	N/A	Emissions to air.	Secondary	Good
VOCs, total	VOCs (unspecified)	N/A	N/A	N/A	Emissions to air.	Secondary	Good

Waste	Database(s)	Source	Temporal Information	Regional Coverage	Technology Coverage	Data Type	Data Quality
Non-hazardous waste to municipal solid waste	Municipal solid waste {RoW}| treatment of municipal solid waste, sanitary landfill | Cut-off, U	ecoinvent 3	2021	Rest of World	This dataset represents the activity of waste disposal of 'municipal solid waste' in a sanitary landfill.	Secondary	Good
Hazardous waste to incineration	Hazardous waste, for incineration {RoW}| treatment of hazardous waste, hazardous waste incineration | Cut-off, U	ecoinvent 3	2021	Rest of World	This dataset represents the activity of waste disposal of 'hazardous waste' by incineration without energy recovery.	Secondary	Good
Wastewater	Wastewater, average {RoW}| treatment of wastewater, average, wastewater treatment | Cut-off, U	ecoinvent 3	2021	Rest of World	This dataset represents the treatment of a wastewater, generated from an ordinary transforming activity. Purification in wastewater treatment of 'wastewater, average'.	Secondary	Good
Distribution	**Database(s)**	**Source**	**Temporal Information**	**Regional Coverage**	**Technology Coverage**	**Data Type**	**Data Quality**
Truck	Transport, combination truck, average fuel mix/US	USLCI	2008	United States	This dataset includes vehicle operation and mixing process for combination truck, assuming 100% diesel and 0% gasoline.	Secondary	Fine

Installation	Database(s)	Source	Temporal Information	Regional Coverage	Technology Coverage	Data Type	Data Quality
Plastic Incineration	Waste plastic, mixture {GLO}| treatment of waste plastic, mixture, municipal incineration | Cut-off, U	ecoinvent 3	2023	Global	The activity starts with the waste being available at the gate of the treatment facility. Collection and transportation of the waste to the treatment plant is not included. The activity ends with the waste being treated and waste-specific emissions from the incineration process and auxiliary material consumption for flue gas cleaning are released to the environment (air and water). Infrastructure and waste-specific energy demands for Municipal Solid Waste Incineration (MSWI) and net energy generation are included.	Secondary	Good
Paper and Wood Incineration	Waste paperboard {GLO}| treatment of waste paperboard, municipal incineration | Cut-off, U	ecoinvent 3	2023	Global	The activity starts with the waste being available at the gate of the treatment facility. Collection and transportation of the waste to the treatment plant is not included. The activity ends with the waste being treated and waste-specific emissions from the incineration process and auxiliary material consumption for flue gas cleaning are released to the environment (air and water). Infrastructure and waste-specific energy demands for Municipal Solid Waste Incineration (MSWI) and net energy generation are included.	Secondary	Good
Plastic to Landfill	Waste plastic, mixture {RoW}| treatment of waste plastic, mixture, sanitary landfill | Cut-off, U	ecoinvent 3	2023	Rest of World	The activity starts with the waste being available at the gate of the treatment facility. Collection and transportation of the waste to the treatment plant is not included. The activity ends with the waste being treated and waste-specific emissions from the landfill are released to the environment (air due to landfill gas, water due to landfill leachate, and subsequent into groundwater).	Secondary	Good
Paper and Wood to Landfill	Waste paperboard {RoW}| treatment of waste paperboard, sanitary landfill | Cut-off, U	ecoinvent 3	2023	Rest of World	The activity starts with the waste being available at the gate of the treatment facility. Collection and transportation of the waste to the treatment plant is not included. The activity ends with the waste being treated and waste-specific emissions from the landfill are released to the environment (air due to landfill gas, water due to landfill leachate, and subsequent into groundwater).	Secondary	Good
Steel Packaging to Landfill	Scrap steel {RoW}| treatment of scrap steel, inert material landfill | Cut-off, U	ecoinvent 3	2023	Rest of World	The activity starts with the waste being available at the gate of the treatment facility. Collection and transportation of the waste to the treatment plant is not included. The activity ends with the waste being treated. No direct emissions from inert material landfill (leachate) are inventoried as deemed negligible. Module contains only exchanges to process-specific burdens (energy, land use) and infrastructure.	Secondary	Good

Installation	Database(s)	Source	Temporal Information	Regional Coverage	Technology Coverage	Data Type	Data Quality
Steel Packaging Incineration	Scrap steel {RoW}| treatment of scrap steel, municipal incineration | Cut-off, U	ecoinvent 3	2023	Rest of World	The process represents the treatment of 'scrap steel' in a municipal solid waste incinerator (MSWI). The activity starts with the waste being available at the gate of the treatment facility. Collection and transportation of the waste to the treatment plant is not included. The activity ends with the waste being treated and waste-specific emissions from the incineration process and auxiliary material consumption for flue gas cleaning are released to the environment (air and water). Infrastructure and waste-specific energy demands for Municipal Solid Waste Incineration (MSWI) and net energy generation are included.	Secondary	Good
Mortar Mix	Cement mortar {RoW}| cement mortar production | Cut-off, U	ecoinvent 3	2023	Rest of World	Includes the whole manufacturing process to produce cement mortar (raw material provision, raw material mixing, packing, and storage), transports to plant, and infrastructure. No requirements for administration are included. No additional buildings and land-use have been taken into account as it is assumed that the mixing process takes place in an existing building of the sand/cement industry or on the construction site	Secondary	Good
	Tap water {RoW}| market for tap water | Cut-off, U	ecoinvent 3	2023	Rest of World	This dataset describes average tap water available, at user, on a global level. Since tap water is mainly produced and distributed at a regional level, regional markets should be preferred, when relevant.	Secondary	Good
Truck for Disposal	Transport, refuse truck, diesel powered/tkm/RNA	USLCI	2011	United States	This dataset includes vehicle operation, including running, idling, non-running emissions, and off-network activity.	Secondary	Fine
Brick Waste	Waste brick {RoW}| treatment of waste brick, collection for final disposal | Cut-off, U	ecoinvent 3	2016	Rest of World	The activity starts with the input of brick material for disposal. The activity ends with energy for dismantling, particulate matter emissions from dismantling and handling, transport to dismantling facilities, and final disposal of waste material.	Secondary	Good
Sand	Sand {RoW}| market for sand | Cut-off, U	ecoinvent 3	2023	Rest of World	This activity starts at the gate of the activities that produce 'sand', within the geography of Global. This activity ends with the supply of 'sand', to the consumers of this product. Transport is included. Product losses during transportation are assumed negligible and are therefore not included.	Secondary	Good
Gasoline	Gasoline, combusted in equipment/US	USLCI	2008	United States	Gasoline combustion in equipment such as mobile refrigeration units, generators, pumps, and portable well-drilling equipment.	Secondary	Fine

Maintenance	Database(s)	Source	Temporal Information	Regional Coverage	Technology Coverage	Data Type	Data Quality
Cleaning Agent	Hydrochloric acid, without water, in 30% solution state {RoW}| market for hydrochloric acid, without water, in 30% solution state | Cut-off, U	ecoinvent 3	2023	Rest of World	This activity starts at the gate of the activities that produce 'hydrochloric acid, without water, in 30% solution state', within the geography of Global. This activity ends with the supply of 'hydrochloric acid, without water, in 30% solution state', to the consumers of this product. Transport is included. Product losses during transportation are assumed negligible and are therefore not included.	Secondary	Good
	Tap water {RoW}| market for tap water | Cut-off, U	ecoinvent 3	2021	Rest of World	This dataset describes average tap water available, at user, on a global level. Since tap water is mainly produced and distributed at a regional level, regional markets should be preferred, when relevant.	Secondary	Good
Water for Cleaning	Tap water {RoW}| market for tap water | Cut-off, U	ecoinvent 3	2021	Rest of World	This dataset describes average tap water available, at user, on a global level. Since tap water is mainly produced and distributed at a regional level, regional markets should be preferred, when relevant.	Secondary	Good
Gasoline	Gasoline, combusted in equipment/US	USLCI	2008	United States	Gasoline combustion in equipment such as mobile refrigeration units, generators, pumps, and portable well-drilling equipment.	Secondary	Fine
Cleaning Agent Emissions	Hydrochloric acid	N/A	N/A	N/A	Emissions to soil.	Secondary	Good
Disposal Transportation	**Database(s)**	**Source**	**Temporal Information**	**Regional Coverage**	**Technology Coverage**	**Data Type**	**Data Quality**
Truck for Disposal	Transport, refuse truck, diesel powered/tkm/RNA	USLCI	2011	United States	This dataset includes vehicle operation, including running, idling, non-running emissions, and off-network activity.	Secondary	Fine

Disposal	Database(s)	Source	Temporal Information	Regional Coverage	Technology Coverage	Data Type	Data Quality
Brick Waste	Waste brick {RoW}| treatment of waste brick, collection for final disposal | Cut-off, U	ecoinvent 3	2016	Rest of World	The activity starts with the input of brick material for disposal. The activity ends with energy for dismantling, particulate matter emissions from dismantling and handling, transport to dismantling facilities, and final disposal of waste material.	Secondary	Good
Recovery	**Database(s)**	**Source**	**Temporal Information**	**Regional Coverage**	**Technology Coverage**	**Data Type**	**Data Quality**
Recovered Brick	Gravel, round {RoW}| gravel and sand quarry operation | Cut-off, U	ecoinvent 3	2018	Rest of World	The multioutput-process 'mining, gravel / sand' delivers the co-products 'sand, at mine' and 'gravel, round, at mine'. The typical production mix in Switzerland is: sand 35% and round gravel 65%. From the total sectoral production volume (100%) of mined gravel round, crushed and sand, about 85% is gravel round and sand.	Secondary	Good

Appendix C: EPD and Scaling Factor Tables

Table C. 1 – Clay Brick & Structural Clay Tile TRACI v2.2 Impact Assessment

Parameter	Unit	A1-A3	A4	A5 Brick Impacts	A5 Mortar Impacts	B2	C2	C4	D
GWP	kg CO_2-Eq.	3.87E+01	4.80E+00	2.42E+00	8.25E+00	0.00E+00	1.54E+00	2.38E+00	-6.89E-02
ODP	kg CFC-11 Eq.	3.08E-08	1.82E-10	3.98E-09	3.72E-08	0.00E+00	6.45E-11	4.80E-08	-7.10E-10
AP Air	kg SO_2-Eq.	3.47E-01	2.86E-02	2.05E-02	2.62E-02	0.00E+00	2.03E-02	1.32E-02	-4.18E-04
FEP	kg P-Eq.	7.57E-04	5.42E-06	1.26E-04	8.50E-04	0.00E+00	1.92E-06	1.40E-04	-1.27E-05
MEP	kg N-Eq.	1.28E-02	6.53E-03	1.43E-03	4.46E-03	0.00E+00	5.38E-03	3.08E-03	-8.07E-05
SP	kg O_3-Eq.	1.59E+00	7.84E-01	1.64E-01	5.02E-01	0.00E+00	5.22E-01	3.64E-01	-9.01E-03

Table C. 2 – Clay Brick & Structural Clay Tile Resource Use Impact Assessment

Parameter	Unit	A1-A3	A4	A5 Brick Impacts	A5 Mortar Impacts	B2	C2	C4	D
RPRE	MJ	2.07E+00	0.00E+00	1.28E-01	6.74E+00	0.00E+00	0.00E+00	4.73E-01	-6.98E-02
RPRM	MJ	4.4E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NRPRE	MJ	5.25E+02	6.17E+01	3.06E+01	2.42E+01	0.00E+00	2.21E+01	3.64E+00	-3.74E-01
NRPRM	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SM	kg	4.09E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RSF	MJ	1.59E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NRSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RE	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FW	m^3	4.21E-02	0.00E+00	2.95E-03	4.44E-02	0.00E+00	0.00E+00	2.04E-02	-2.32E-02

Table C. 3 – Clay Brick & Structural Clay Tile Output Flows and Waste Categories Impact Assessment

Parameter	Unit	A1-A3	A4	A5		B2	C2	C4	D
				Brick Impacts	Mortar Impacts				
HWD	kg	7.95E-05	0.00E+00	1.76E-05	2.18E-04	0.00E+00	0.00E+00	2.70E-04	-4.48E-06
NHWD	kg	5.89E-01	0.00E+00	5.66E+00	9.57E-01	0.00E+00	0.00E+00	1.12E+02	-7.93E-03
HLRW	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ILLRW	kg	3.58E-05	0.00E+00	2.15E-06	3.75E-05	0.00E+00	0.00E+00	6.95E-06	-1.16E-06
CRU	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MR	kg	0.00E+00	0.00E+00	8.56E-01	0.00E+00	0.00E+00	0.00E+00	1.52E+01	0.00E+00
MER	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EE	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table C. 4 – Clay Brick & Structural Clay Tile Biogenic Carbon Impact Assessment

Parameter	Unit	A1-A3	A4	A5		B2	C2	C4	D
				Brick Impacts	Mortar Impacts				
BCRP	kg CO_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BCEP	kg CO_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BCRK	kg CO_2	4.44E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BCEK	kg CO_2	0.00E+00	0.00E+00	4.44E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BCEW	kg CO_2	6.49E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CCE	kg CO_2	5.79E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CCR	kg CO_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CWNR	kg CO_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BCRP	kg CO_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table C. 5 – Clay Brick & Structural Clay Tile CML 4.1 Impact Assessment

Parameter	Unit	A1-A3	A4	A5 Brick Impacts	A5 Mortar Impacts	B2	C2	C4	D
GWP	kg CO_2-Eq.	3.92E+01	4.81E+00	2.46E+00	8.31E+00	0.00E+00	1.55E+00	2.40E+00	-6.9E-02
ODP	kg CFC-11 Eq.	2.72E-08	1.81E-10	3.21E-09	4.03E-09	0.00E+00	6.44E-11	3.64E-08	-5.54E-10
AP Air	kg SO_2-Eq.	3.39E-01	2.36E-02	1.94E-02	2.31E-02	0.00E+00	1.56E-02	1.06E-02	-3.61E-04
EP	kg$(PO_4)^3$-Eq.	1.37E-02	4.19E-03	1.81E-03	8.80E-03	0.00E+00	3.40E-03	2.97E-03	-1.40E-04
POCP	kg C_2H_4-Eq.	2.06E-02	1.09E-03	9.50E-04	1.01E-03	0.00E+00	-3.3E-03	4.92E-04	-2.4E-05
ADPE	kg Sb-Eq.	5.47E-05	0.00E+00	3.01E-06	2.05E-05	0.00E+00	0.00E+00	5.43E-06	-3.6E-07
ADPF	MJ	5.22E+02	6.17E+01	3.05E+01	2.17E+01	0.00E+00	2.21E+01	3.16E+00	-2.97E-01

Table C. 6 – Clay Brick & Structural Clay Tile Scaling Factor Table

Unit Size Designation	ASTM Specification	Dimensions (inches) (W x H x L)	Dimensions (cm) (W x H x L)	Void Space of Brick (%)	Mass of Brick/Tile (kg/unit)	No. of Units/m2 (0.95 cm joint)	Brick Conversion Factor	Mortar Mass (kg/m2)	Mortar Conversion Factor
Modular	*C216*	*3.625 x 2.25 x 7.625*	*9.2 x 5.7 x 19.4*	*<25%*	*1.72*	*73.81*	*1.000*	*32.77*	*1.000*
Ambassador	*C216*	*3.625 x 2.25 x 15.625*	*9.2 x 5.7 x 39.7*	*<25%*	*3.40*	*36.90*	*0.988*	*29.17*	*0.890*
Closure	*C216*	*3.625 x 3.625 x 7.625*	*9.2 x 9.2 x 19.4*	*<25%*	*2.60*	*48.44*	*0.992*	*24.39*	*0.744*
Engineer	*C216*	*3.625 x 2.625 x 7.625*	*9.2 x 6.7 x 19.4*	*<25%*	*2.13*	*64.58*	*1.084*	*29.72*	*0.907*
King	*C216*	*2.75 x 2.625 x 9.625*	*7 x 6.7 x 24.4*	*<25%*	*1.97*	*51.67*	*0.802*	*21.43*	*0.654*
Norman	*C216*	*3.625 x 2.25 x 11.625*	*9.2 x 5.7 x 29.5*	*<25%*	*2.27*	*49.21*	*0.880*	*30.37*	*0.927*
Roman	*C216*	*3.625 x 1.625 x 11.625*	*9.2 x 4.1 x 29.5*	*<25%*	*1.87*	*64.58*	*0.951*	*38.11*	*1.163*
Utility	*C216*	*3.625 x 3.625 x 11.625*	*9.2 x 9.2 x 29.5*	*<25%*	*4.08*	*32.29*	*1.038*	*21.85*	*0.667*
Fireback Split	*C1261*	*1.25 x 4.5 x 9*	*3.2 x 11.4 x 22.9*	*0.0%*	*1.68*	*33.91*	*0.449*	*7.03*	*0.214*
Fireback Full	*C1261*	*2.5 x 4.5 x 9*	*6.4 x 11.4 x 22.9*	*0.0%*	*3.27*	*33.91*	*0.874*	*14.06*	*0.429*

Table C. 7 – Clay Brick Pavers TRACI v2.2 Impact Assessment

Parameter	Unit	A1-A3	A4	A5	B2	C2	C4	D
GWP	kg CO_2-Eq.	5.66E+01	7.01E+00	3.54E+00	1.63E+00	2.25E+00	3.48E+00	-1.01E-01
ODP	kg CFC-11 Eq.	4.50E-08	2.65E-10	5.81E-09	1.54E-07	9.43E-11	7.02E-08	-1.04E-09
AP Air	kg SO_2-Eq.	5.07E-01	4.19E-02	3.00E-02	1.07E-02	2.97E-02	1.93E-02	-6.11E-04
FEP	kg P-Eq.	1.11E-03	7.92E-06	1.84E-04	2.94E-04	2.81E-06	2.05E-04	-1.85E-05
MEP	kg N-Eq.	1.88E-02	9.54E-03	2.09E-03	1.89E-03	7.87E-03	4.51E-03	-1.18E-04
SP	kg O_3-Eq.	2.33E+00	1.15E+00	2.40E-01	2.36E-01	7.63E-01	5.32E-01	-1.32E-02

Table C. 8 – Clay Brick Pavers Resource Use Impact Assessment

Parameter	Unit	A1-A3	A4	A5	B2	C2	C4	D
RPRE	MJ	3.03E+00	0.00E+00	1.87E-01	1.51E+00	0.00E+00	6.92E-01	-1.02E-01
RPRM	MJ	6.37E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NRPRE	MJ	7.67E+02	9.02E+01	4.48E+01	1.46E+01	3.23E+01	5.32E+00	-5.47E-01
NRPRM	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SM	kg	5.98E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RSF	MJ	2.33E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NRSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RE	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FW	m^3	6.16E-02	0.00E+00	4.32E-03	1.83E-01	0.00E+00	2.99E-02	-3.39E-02

Table C. 9 – Clay Brick Pavers Output Flows and Waste Categories Impact Assessment

Parameter	Unit	A1-A3	A4	A5	B2	C2	C4	D
HWD	kg	1.16E-04	0.00E+00	2.57E-05	4.47E-04	0.00E+00	3.94E-04	-6.55E-06
NHWD	kg	8.61E-01	0.00E+00	8.28E+00	9.77E-02	0.00E+00	1.63E+02	-1.16E-02
HLRW	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ILLRW	kg	5.24E-05	0.00E+00	3.14E-06	2.33E-05	0.00E+00	1.02E-05	-1.70E-06
CRU	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MR	kg	0.00E+00	0.00E+00	1.25E+00	0.00E+00	0.00E+00	2.23E+01	0.00E+00
MER	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EE	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table C. 10 – Clay Brick Pavers Biogenic Carbon Impact Assessment

Parameter	Unit	A1-A3	A4	A5	B2	C2	C4	D
BCRP	kg CO_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.0E+00	0.0E+00	0.0E+00
BCEP	kg CO_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.0E+00	0.0E+00	0.0E+00
BCRK	kg CO_2	6.48E-01	0.0E+00	0.0E+00	0.00E+00	0.0E+00	0.0E+00	0.0E+00
BCEK	kg CO_2	0.0E+00	0.0E+00	0.0E+00	0.00E+00	0.0E+00	0.0E+00	0.0E+00
BCEW	kg CO_2	9.49E-04	0.0E+00	0.0E+00	0.00E+00	0.0E+00	0.0E+00	0.0E+00
CCE	kg CO_2	8.5E+00	0.0E+00	0.0E+00	0.00E+00	0.0E+00	0.0E+00	0.0E+00
CCR	kg CO_2	0.00E+00	0.0E+00	0.0E+00	0.00E+00	0.0E+00	0.0E+00	0.0E+00
CWNR	kg CO_2	0.00E+00	0.0E+00	0.0E+00	0.00E+00	0.0E+00	0.0E+00	0.0E+00
BCRP	kg CO_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.0E+00	0.0E+00	0.0E+00

Table C. 11 – Clay Brick Pavers CML 4.1 Impact Assessment

Parameter	Unit	A1-A3	A4	A5	B2	C2	C4	D
GWP	kg CO_2-Eq.	5.73E+01	7.03E+00	3.59E+00	1.64E+00	2.26E+00	3.51E+00	-1.01E-01
ODP	kg CFC-11 Eq.	3.98E-08	2.65E-10	4.70E-09	1.45E-07	9.41E-11	5.32E-08	-8.10E-10
AP Air	kg SO_2-Eq.	4.95E-01	3.45E-02	2.84E-02	9.62E-03	2.27E-02	1.55E-02	-5.28E-04
EP	kg$(PO_4)^3$-Eq.	2.01E-02	6.12E-03	2.64E-03	3.30E-03	4.97E-03	4.33E-03	-2.04E-04
POCP	kg C_2H_4-Eq.	3.01E-02	1.59E-03	1.39E-03	9.77E-04	-4.85E-03	7.19E-04	-3.44E-05

ADPE	kg Sb-Eq.	8.00E-05	0.00E+00	4.40E-06	1.69E-05	0.00E+00	7.94E-06	-5.29E-07
ADPF	MJ	7.63E+02	9.02E+01	4.46E+01	1.31E+01	3.23E+01	4.61E+00	-4.35E-01

Table C. 12 – Clay Brick Pavers Scaling Factor Table

Paver Designation	ASTM Specification	Dimensions (inches) (W x H x L)	Dimensions (cm) (W x H x L)	Void Space of Brick (%)	Mass of Paver (kg/unit)	No. of Units/m^2 (0.32 cm joint)	Brick Conversion Factor
STD Full	*C902*	*2.25 x 3.75 x 8*	*5.7 x 9.5 x 20.3*	*0.0%*	*2.31*	*80.32*	*1.000*
Paver	*C902*	*3.625 x 2.25 x 7.625*	*9.2 x 5.7 x 19.4*	*0.0%*	*2.09*	*53.33*	*0.601*
STD Split	*C902*	*1.25 x 3.75 x 8*	*3.2 x 9.5 x 20.3*	*0.0%*	*1.08*	*138.74*	*0.808*
Paver split	*C902*	*1.25 x 2.25 x 7.625*	*3.2 x 5.7 x 19.4*	*0.0%*	*1.27*	*145.45*	*0.996*
Jumbo	*C902*	*3 x 3.5 x 11.5*	*7.6 x 8.9 x 29.2*	*0.0%*	*4.22*	*42.67*	*0.970*
Bnose 9	*C216*	*2.19 x 3.5 x 9*	*5.6 x 8.9 x 22.9*	*<25%*	*2.27*	*73.38*	*0.898*
Bnose 12	*C216*	*2.19 x 3.5 x 12*	*5.6 x 8.9 x 30.5*	*<25%*	*2.81*	*55.22*	*0.836*

Table C. 13 – Thin Brick TRACI v2.2 Impact Assessment

Parameter	Unit	A1-A3	A4	A5		B2	C2	C4	D
				Brick Impacts	Mortar Impacts				
GWP	kg CO_2-Eq.	4.53E+01	1.00E+00	5.07E-01	2.98E+00	0.00E+00	3.22E-01	4.98E-01	-1.44E-02
ODP	kg CFC-11 Eq.	3.60E-08	3.80E-11	8.32E-10	1.34E-08	0.00E+00	1.35E-11	1.00E-08	-1.49E-10
AP Air	kg SO_2-Eq.	4.06E-01	6.00E-03	4.29E-03	9.44E-03	0.00E+00	4.26E-03	2.77E-03	-8.76E-05
FEP	kg P-Eq.	8.85E-04	1.13E-06	2.63E-05	3.07E-04	0.00E+00	4.03E-07	2.93E-05	-2.65E-06
MEP	kg N-Eq.	1.50E-02	1.37E-03	2.99E-04	1.61E-03	0.00E+00	1.13E-03	6.46E-04	-1.69E-05
SP	kg O_3-Eq.	1.86E+00	1.64E-01	3.43E-02	1.81E-01	0.00E+00	1.09E-01	7.62E-02	-1.89E-03

Table C. 14 – Thin Brick Resource Use Impact Assessment

Parameter	Unit	A1-A3	A4	A5		B2	C2	C4	D
				Brick Impacts	Mortar Impacts				
RPRE	MJ	2.42E+00	0.00E+00	2.67E-02	2.43E+00	0.00E+00	0.00E+00	9.91E-02	-1.46E-02
RPRM	MJ	5.09E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NRPRE	MJ	6.13E+02	1.29E+01	6.41E+00	8.72E+00	0.00E+00	4.62E+00	7.62E-01	-7.83E-02
NRPRM	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SM	kg	4.78E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RSF	MJ	1.86E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NRSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RE	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FW	m^3	4.92E-02	0.00E+00	6.18E-04	1.60E-02	0.00E+00	0.00E+00	4.28E-03	-4.85E-03

Table C. 15 – Thin Brick Output Flows and Waste Categories Impact Assessment

Parameter	Unit	A1-A3	A4	A5		B2	C2	C4	D
				Brick Impacts	Mortar Impacts				
HWD	kg	9.29E-05	0.00E+00	3.68E-06	7.87E-05	0.00E+00	0.00E+00	5.64E-05	-9.38E-07
NHWD	kg	6.88E-01	0.00E+00	1.19E+00	3.45E-01	0.00E+00	0.00E+00	2.34E+01	-1.66E-03
HLRW	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ILLRW	kg	4.19E-05	0.00E+00	4.49E-07	1.35E-05	0.00E+00	0.00E+00	1.45E-06	-2.43E-07
CRU	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MR	kg	0.00E+00	0.00E+00	1.79E-01	0.00E+00	0.00E+00	0.00E+00	3.19E+00	0.00E+00
MER	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EE	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table C. 16 – Thin Brick Biogenic Carbon Impact Assessment

Parameter	Unit	A1-A3	A4	A5 Brick Impacts	A5 Mortar Impacts	B2	C2	C4	D
BCRP	kg CO_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BCEP	kg CO_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BCRK	kg CO_2	5.18E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BCEK	kg CO_2	0.00E+00	0.00E+00	5.18E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BCEW	kg CO_2	1.36E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CCE	kg CO_2	6.76E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CCR	kg CO_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CWNR	kg CO_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BCRP	kg CO_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table C. 17 – Thin Brick CML 4.1 Impact Assessment

Parameter	Unit	A1-A3	A4	A5 Brick Impacts	A5 Mortar Impacts	B2	C2	C4	D
GWP	kg CO_2-Eq.	4.58E+01	1.01E+00	5.14E-01	3.00E+00	0.00E+00	3.24E-01	5.03E-01	-1.45E-02
ODP	kg CFC-11 Eq.	3.18E-08	3.79E-11	6.72E-10	1.45E-09	0.00E+00	1.35E-11	7.62E-09	-1.16E-10
AP Air	kg SO_2-Eq.	3.96E-01	4.95E-03	4.07E-03	8.33E-03	0.00E+00	3.26E-03	2.23E-03	-7.56E-05
EP	kg$(PO_4)^3$-Eq.	1.60E-02	8.77E-04	3.78E-04	3.17E-03	0.00E+00	7.12E-04	6.21E-04	-2.93E-05
POCP	kg C_2H_4-Eq.	2.41E-02	2.28E-04	1.99E-04	3.64E-04	0.00E+00	-6.94E-04	1.03E-04	-4.93E-06
ADPE	kg Sb-Eq.	6.40E-05	0.00E+00	6.30E-07	7.41E-06	0.00E+00	0.00E+00	1.14E-06	-7.58E-08
ADPF	MJ	6.10E+02	1.29E+01	6.38E+00	7.81E+00	0.00E+00	4.62E+00	6.60E-01	-6.22E-02

Table C. 18 – Thin Brick Scaling Factor Table

Unit Size Designation	ASTM Specification	Dimensions (inches) (W x H x L)	Dimensions (cm) (W x H x L)	Mass of Brick/Tile (kg/unit)	No. of Units/m^2 (0.95 cm joint)	Brick Conversion Factor	Mortar Mass (kg/m^2)	Mortar Conversion Factor
Mod Thin Brick	*C1088*	*0.625 x 2.25 x 7.625*	*1.6 x 5.7 x 19.4*	*0.36*	*73.81*	*1.000*	*11.823*	*1.000*

Appendix D: EPD Generator Parameters

The following are all parameters that are used in the model to determine process inputs. Any units listed "/kg" are inputs per kilogram of brick product, not per functional unit.

Table D. 1 – EPD Generator Parameters Descriptions

Parameter	Unit	Description
Mining	-	Adds mining inputs into the A1 stage if facility does not mine
Thin Brick Factor	-	Is 1 if facility extrudes thin brick directly. Is 5.583 if it saws
A1_Clay	kg/kg	Amount of mined clay per kg of brick (raw material)
A1_Grog	kg/kg	Amount of external grog per kg of brick (raw material)
A1_Pigments	kg/kg	Amount of pigment additives per kg of brick (raw material)
A1_Body_additives	kg/kg	Amount of body additives per kg of brick (raw material)
A1_Sand	kg/kg	Amount of sand additive per kg of brick (raw material)
A2_Transp_Rail	kgkm/kg	Transportation of raw materials via train
A2_Transp_Truck	kgkm/kg	Transportation of raw materials via truck
A3_Electricity_Grid	kWh/kg	Total electricity used in manufacturing
A3_Electricity_SPSO	kWh/kg	Electricity used in manufacturing from the SPSO eGrid
A3_Electricity_ERCT	kWh/kg	Electricity used in manufacturing from the ERCT eGrid
A3_Electricity_RFCW	kWh/kg	Electricity used in manufacturing from the RFCW eGrid
A3_Electricity_MROW	kWh/kg	Electricity used in manufacturing from the MROW eGrid
A3_Electricity_SRVC	kWh/kg	Electricity used in manufacturing from the SRVC eGrid
A3_Electricity_SRSO	kWh/kg	Electricity used in manufacturing from the SRSO eGrid
A3_Electricity_RFCE	kWh/kg	Electricity used in manufacturing from the RFCE eGrid
A3_Electricity_CAMX	kWh/kg	Electricity used in manufacturing from the CAMX eGrid
A3_Electricity_NWPP	kWh/kg	Electricity used in manufacturing from the NWPP eGrid
A3_Electricity_Poland	kWh/kg	Electricity used in manufacturing from the Poland grid
A3_Electricity_NEWE	kWh/kg	Electricity used in manufacturing from the NEWE eGrid
A3_Electricity_RMPA	kWh/kg	Electricity used in manufacturing from the RMPA eGrid
A3_Electricity_Solar	kWh/kg	Electricity used in manufacturing from onsite solar power
A3_Electricity_Wind	kWh/kg	Electricity used in manufacturing from onsite wind power
A3_Natural_Gas	ft3/kg	Natural gas combusted in manufacturing
A3_Diesel	gal/kg	Diesel combusted in manufacturing
A3_Hard_coal	ton/kg	Hard coal combusted in manufacturing
A3_Gasoline	gal/kg	Gasoline combusted in manufacturing
A3_Propane	gal/kg	Propane combusted in manufacturing
A3_Methane_landfill	ft^3/kg	Landfill methane combusted in manufacturing
A3_Sawdust	tons/kg	Recycled sawdust combusted in manufacturing
A3_Transport	kgkm/kg	Transportation of materials and fuels for manufacturing
A3_Hydrated_Lime	kg/kg	Hydrated lime used as a support material in manufacturing
A3_Limestone	kg/kg	Limestone used as a support material in manufacturing
A3_Sodium_bicarbonate	kg/kg	$NaHCO_3$ used as a support material in manufacturing

A3_White_mineral_oil	kg/kg	White mineral oil used as a support material in manufacturing
A3_Tap_Water	kg/kg	Tap water used in manufacturing
A3_Well_Water	kg/kg	Well water used in manufacturing
A3_Plastic_Pkg	kg/kg	Plastic straps used to ship the product
A3_Steel_Pkg	kg/kg	Steel straps used to ship the product
A3_Paper_Pkg	kg/kg	Paper packaging used to ship the product
A3_Wood_Pkg	ft3/kg	Wood packaging used to ship the product
A3_Pallets	ft3/kg	Pallets used to ship the product
A3_Nonhaz_Waste	kg/kg	Nonhazardous waste produced in manufacturing
A3_Haz_Waste	kg/kg	Hazardous waste produced in manufacturing
A3_Wastewater	gal/kg	Wastewater produced in manufacturing
A3_Carbon_dioxide	kg/kg	Carbon dioxide emitted by firing process emissions
A3_Carbon_monoxide	kg/kg	Carbon monoxide emitted by firing process emissions
A3_Chlorine	kg/kg	Gaseous chloride emitted by firing process emissions
A3_Hydrogen_chloride	kg/kg	Hydrogen chloride emitted by firing process emissions
A3_Hydrogen_fluoride	kg/kg	Hydrogen fluoride emitted by firing process emissions
A3_Lead	kg/kg	Gaseous lead emitted by firing process emissions
A3_Mercury	kg/kg	Gaseous mercury emitted by firing process emissions
A3_CH4	kg/kg	Methane emitted by firing process emissions
A3_Nitrogen_dioxide	kg/kg	Nitrogen dioxide emitted by firing process emissions
A3_Nitrogen_oxides	kg/kg	Nitrogen oxide emitted by firing process emissions
A3_particles_PM2_5	kg/kg	Particulates (>2.5 um) emitted by firing process emissions
A3_particles_PM10	kg/kg	Particulates (>10 um) emitted by firing process emissions
A3_Sulfur_dioxide	kg/kg	Sulfur dioxide emitted by firing process emissions
A3_VOC_unspecified	kg/kg	VOC emitted by firing process emissions