Sustainable Minds
Design greener products right, from the start

LIFE CYCLE ASSESSMENT (LCA) OF TOTO SANITARY CERAMIC PRODUCTS

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Client	TOTO USA
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Contents

1 GENERAL

TOTO is the world's largest plumbing products manufacturer and offers a complete line of commercial and decorative plumbing fixtures and fittings, including toilets, lavatory sinks, urinals, faucets, flush valves, showerheads and valves, bathtubs, and their accessories. TOTO products infuse style with substance, optimize water conservation and strive for consistent and high performance. TOTO embraced water and energy conservation years before government mandates. Through their consistently evolving manufacturing practices, they aim to develop and manufacture plumbing fixtures that are efficient and sustainable. For more information on TOTO products, go to www.totousa.com.

Team

This report is based on the work of the following LCA project team members on behalf of TOTO:

- Bill Strang, Project Sponsor
- Kristen Girts, Project Manager & Associate Quality Engineer
- Natala Stroman, Product Engineer
- Fred Kirksey, Product Engineer

They have been assisted by numerous TOTO USA and TOTO Mexico employees during the product group definition, data collection, reporting and interpretation.

From Sustainable Minds:

- Naji Kasem, LCA Practitioner
- Kim Lewis, LCA Practitioner
- Millali Marcano, Project Manager

2 SCOPE

In order to understand the true impact of products throughout all life cycle stages, TOTO has chosen to conduct the Life Cycle Assessment using a cradle-to-grave approach. By factoring in all stages, we are more informed on how to reduce impacts on a broader scale. TOTO is the first company in the U.S. plumbing industry to conduct a cradle-to-grave LCA.

3 CONTENT, STRUCTURE, AND ACCESSIBILITY OF THE PROJECT REPORT

All information in the report reflects the best possible inventory by TOTO at the time it was collected and best practices were conducted by Sustainable Minds and TOTO employees to transform this information into this LCA report. The data covers annual manufacturing data for the year 2013 from of one of TOTO USA's suppliers, TOTO Mexico, located in Monterrey Mexico. Most data was supplied directly from TOTO Mexico employees from energy providers or the measured data points from submeters installed in the manufacturing facilities. Some data was calculated by TOTO specialists via engineering calculations and was validated and quality assured by the LCA specialist. Where data was missing, assumptions were made from manufacturing data for the two US facilities based upon expertise from TOTO USA engineers.

This study includes primary data from the processes at TOTO Mexico, secondary data from vendors that have been contracted and literature data to complete the inventory and fill the gaps when necessary.

This report follows the structure of the life cycle assessment methodology defined in the ULE PCR Part A: Calculation Rules for the Life Cycle Assessment and Requirements on the Project report and Part B: Requirements on the EPD for Sanitary Ceramics.

This report includes LCA terminology. To assist the reader, special attention has been given to list definitions of important terms used at the end of this report.

TOTO has chosen to have the LCA data and report go through third party review against ISO 14040/14044. A third party review has been performed by Brad McAllister, WAP Director, who was contracted on behalf of NSF. The review concluded that the report is in conformance with ISO 14040-44. Several comments have been made and responses to them were provided by the LCA specialist. A review statement is included in the appendices of this report.

TOTO has also chosen to have the Transparency Reports undergo third party certification against Parts A and B of the ULE PCR v1.3. A third party review has been performed by Brad McAllister, WAP Director, who was contracted on behalf of NSF. The review concluded that the reports are in conformance with the ULE Part A and Part B. Several comments have been made and responses to them were provided by the LCA specialist. A review statement is included in the appendices of this report.

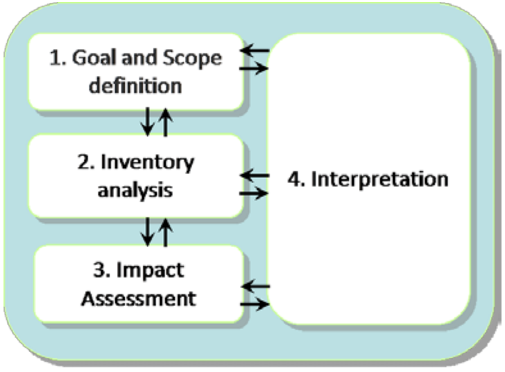
4 GENERAL INFORMATION IN THE PROJECT REPORT

TOTO is interested in having Life Cycle Assessment (LCA) data available for the most important products to be able to obtain a SM Transparency Report, a type III environmental declaration that can be used for communication with and amongst other companies, architects and consumer communication, and can also be utilized in whole building LCA tools.

TOTO commissioned Sustainable Minds to help develop LCA's for the most important ceramic products; However, TOTO wants to develop the internal capacity to develop LCAs. This means that an effort has been made to gather data and to train TOTO staff to model LCAs and how to report on them. TOTO wants to learn from the results and is looking forward to having guidance for future product improvements that can be deduced from the results. This report was published on January 2016.

Life Cycle Assessment

Performing a life cycle assessment (LCA) follows the Sustainable Minds Transparency Report Framework, which is based on ISO 14040-44 & 14025 standards. This report also follows the ULE PCR for Building-Related Products and Services (Part A: Calculation Rules for the Life Cycle Assessment and Requirements on the Project Report and Part B: Requirements on the EPD for Sanitary Ceramics), which is in coordination with EN 15804. Such an LCA includes the following phases:



Source: ISO 14040

- Goal and Scope
- Inventory Analysis
- Impact Assessment
- Interpretation

This report includes all phases.

According to the Framework, a stakeholder procedure is required when LCA results are intended to be used for external communication *and* a comparison is made to products that are not produced by the commissioning party. This report concerns products from TOTO only; therefore, a critical review is not required. An ISO 14040-44 third party review and a third party report certification for transparency reports are mandated by the Framework in order to be able to use transparency reports as Type III environmental declarations. Both of these reviews will be completed in this project.

5 GOAL OF THE STUDY

TOTO USA is committed to innovating products that make people’s lives better, protect the environment and keep our water pure. To honor our commitment to sustainability, it is important that we conduct Life Cycle Assessments to evaluate the environmental impacts of our products in all stages of life, from raw materials to manufacturing and even through to end of life. The goal of conducting a Life Cycle Assessment is to explore the full range of environmental impacts our products have and to identify ways to improve processes and lessen any negative effects. This project is critical to TOTO’s PeoplePlanetWater mission of innovating products for the benefit of people, the planet and our water supply.

This report intends to define the specific application of the LCA methodology to the life cycle of TOTO ceramics. It is intended for both internal (business to business) and external (business to customer) purposes. A Sustainable Minds Transparency Report, a Type III Environmental Declaration per ISO 14025, will communicate the results of this study which is focused on products that are available in the US market.

6 SCOPE OF THE STUDY

The products studied in this report include two ceramic lavatory sinks manufactured in Monterrey, Mexico.

6.1 Declared/Functional unit

The results of the LCA in this report are expressed in terms of functional units as they cover the entire life cycle of the products. The reference service life (RSL) and functional unit for each product are presented in Tables 6.1 and 6.2, respectively. The Transparency Reports of the corresponding products are expressed in terms of one respective piece of the product as well as all life cycle modules which are presented later in this report. The functional units in Table 6.2 are the reference units for the respective products’ LCAs. Reference units express the amount of a product and its function as it is applied and/or used in the United States of America and it includes the lifespan of the product. 20 years is an industry accepted average lifespan that is based on the economic lifespan of the product. This is more limited than the technical lifespan of the product due to changes in consumer preferences and innovations in water usage. The ceramic will easily outlive the 20 years.

Table 6.1 Reference service life (RSL) of the modeled products

Product (s)	Reference Service Life
LT307(A)	20 years of use in an average US commercial environment
LT569	20 years of use in an average US commercial environment

Table 6.2 Functional unit of the modeled products

Name	LT307(A) Value	LT569 Value	Unit
Functional unit	1	1	t
Mass per piece	18.7	8.21	kg
Conversion to 1 kg	0.05347	0.12180	-

6.2 Declaration of construction product classes

The products included in the scope of this study are listed in Table 6.2a. The categories of Transparency Reports and manufacturing locations are presented in Tables 6.2b.Each LCA model represents a specific product from a manufacturer's plant. This is declared in table 6.2c.

Table 6.2a Product codes and names

Product Code	Product Name/Description
LT307(A)	Commercial Wall-Mount Lavatory
LT569	Commercial Undercounter Lavatory

Table 6.2b Vendors and manufacturing locations

Product code	Production plant/vendors	Production location(s)
LT307(A)	TOTO Mexico (TMX)	Monterrey, Mexico
LT569		

Table 6.2c Categories of declarations

Product	Category
LT307(A)	a declaration of a specific product from a manufacturer's plant
LT569	

Manufacturing data has been collected and compiled by TOTO Mexico (TMX) for the year 2013. Table 6.2d lists the 2013 production volumes of the modeled products. Products, their components, and product weight are listed in Table 6.2e below.

Table 6.2d Production volumes of the modeled products (confidential)

Product code	Product Name	Production volume (pieces)
LT307(A)	Commercial Wall-Mount Lavatory	
LT569	Commercial Undercounter Lavatory	

Table 6.2e Ceramic and part weight

Product code	Weight of finished ceramic parts (kg)	Packaging weight (kg)	Parts (kg)
LT307(A)	16.6	1.75	0.346
LT569	7.00	1.08	0.132

The lavatories are designed for use in commercial environments. The classification of commercial lavatories as defined by CSI master format are presented below.

Table 6.2f Product Information

Product code	CSI master format classification	ASTM or ANSI product specification	Physical properties and technical information or any other market identification
LT307(A)	22 42 16.13	ASME A112.19.2/CSA B45.1 Certifications: IAPMO(cUPC)	Vitreous China Plumbing Fixture
LT569	22 42 16.13	ASME A112.19.2/CSA B45.1 Certifications: IAPMO(cUPC)	Vitreous China Plumbing Fixture

6.3 Product description

Table 6.3a and 6.3b present images, descriptions, and technical data of the modeled products. Constructional data is presented in table 6.3c.

Table 6.3a Description of and technical information for LT307(A)

Commercial Wall-Mount Lavatory 	• 21" x 18-1/4" vitreous china lavatory with back splash • 14-15/16" x 10-3/8" basin • 1-1/4" O.D. drain hole • Can be installed at ADA height • Concealed front overflow • Punching for concealed arm carrier • Durable and easy to maintain • Available for 4 inch or 8 inch spread faucets • Soap dispenser hole option See more at the following websites: http://www.totousa.com/commercial-wall-mount-lavatory http://www.totousa.com/commercial-wall-hung-lavatory-soap-dispenser

Table 6.3b Description of and technical information for LT569

Undercounter Lavatory 	• 19-1/4" x 16-1/4" vitreous china undercounter lavatory • 17" x 14" basin • 1-1/4" O.D. drain hole • Installation template and mounting hardware included • Can be installed to meet ADA specifications • Spacious basin • Large backsplash • Concealed front overflow See more at: http://www.totousa.com/undercounter-lavatory-5

Table 6.3c Constructional Data

Name	**LT307(A) Value**	**LT569 Value**	**Unit**
Width	458	411	mm
Length	530	488	mm
Height	283	191	mm
Maximum heat resistance (if relevant)	*	*	°C
Maximum water absorption (if relevant)	*	*	Vol.-%
Harkord-Cracking test	*	*	-
Crazing test	*	*	-
Water absorption test	*	*	-
Impact resistance	*	*	N/cm
Resistance to chemicals and staining	*	*	-
Surface hardness test	*	*	-
Resistance to temperature change	*	*	-
Resistance to dry temperature	*	*	°C

*Where applicable, unit meets or exceeds ASME A112.19.2/CSA B45.1-13

6.4 Area of application of the construction product

The LT307(A) lavatory is a simple, cleanly designed piece that mounts to the wall in any commercial bathroom space, featuring an anti-splash rim, high back and concealed front overflow. The lavatory comes equiped with wall hanger and has been punched for concealed arm carriers. TOTO recommends the use of Jay R. Smith 0700 (Concealed Arms) with 19" arms 0800 (Wall Support Plate). The LT307(A) lavatory meets or exceeds the following standards: ADA, ICC/ANSI A117.1, ASME A112.19.2/CSA B45.1, and TAS. CSI master format designations are provided in table 6.2f.

The LT569 lavatory offers a beautifully rimless, oval design that is installed under the counter in any bathroom space, featuring a generously wide basin, large backsplash and concealed front overflow. The lavatory includes mounting hardware and installation template. The LT569 lavatory meets or exceeds the following standards: ADA, ICC/ANSI A117.1, and ASME A112.19.2/CSA B45.1. CSI master format designations are provided in table 6.2f.

6.5 System boundaries

To define what is and what is not included in an LCA, the system boundaries are drafted. In general, the system boundaries as defined in Part A [6] are followed. This section details some of the aspects to assist the reader to understand what is included in the models.

The system boundaries reflect the life cycle phases that have been modeled. It defines which life cycle phases and processes are included and which excluded. The LCA is modeled according to specific system boundaries and is quantified in such a way that they reflect the respective reference units of the modeled products.

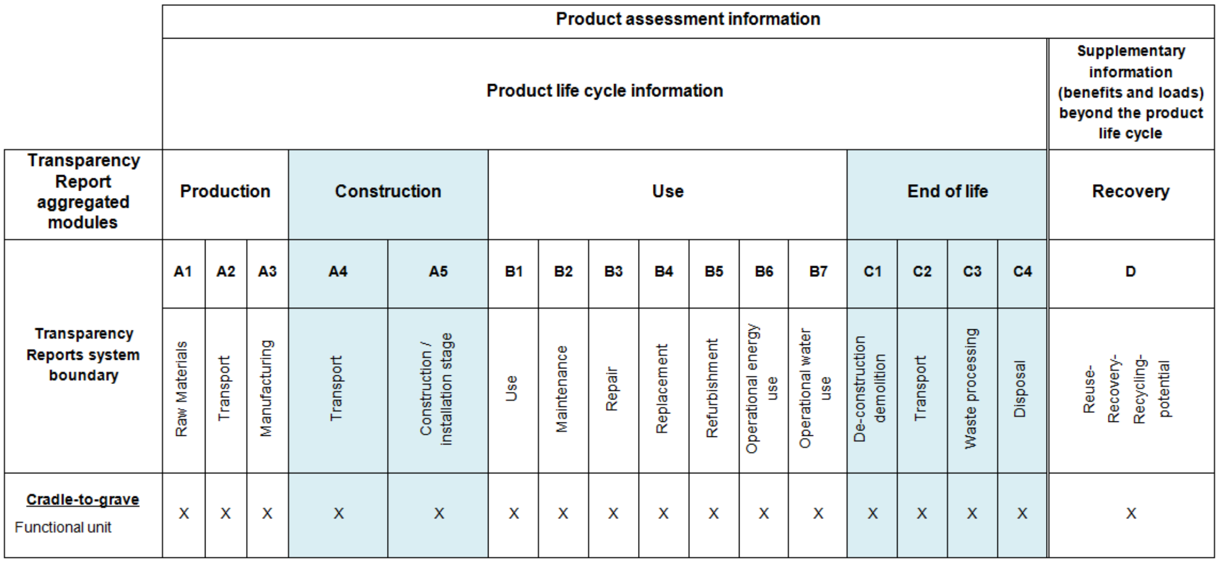
This LCA’s system boundaries include the following life cycle phases:

- Production

- Construction/Installation
- Use
- End of life
- Recovery

These boundaries apply to the modeled products and can be referred to as “cradle-to-grave” which means that it includes all life cycle stages and modules as identified in Part A [6]. Appendix A references the inventory data as modeled in SimaPro. Process flows for each product are provided in section 7.6.

The system boundaries for TOTO ceramic products are detailed below. Figure 6.5 represents the life cycle phases and stages for the entire life cycle of these products.



	Product assessment information																	
	Product life cycle information																	**Supplementary information (benefits and loads) beyond the product life cycle**
Transparency Report aggregated modules	**Production**			**Construction**		**Use**							**End of life**					**Recovery**
	A1	**A2**	**A3**	**A4**	**A5**	**B1**	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**	**C1**	**C2**	**C3**	**C4**		**D**
Transparency Reports system boundary	Raw Materials	Transport	Manufacturing	Transport	Construction / installation stage	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-construction demolition	Transport	Waste processing	Disposal		Reuse- Recovery- Recycling- potential
Cradle-to-grave Functional unit	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X

X = a declared module

Figure 6.5 Applied system boundaries for the modeled ceramic products

6.5.1. A1-A3, Product stage, Information modules

The product stage includes, where relevant, information modules for:

- A1: Extraction and processing of raw materials (e.g. mining processes) and biomass production and processing (e.g. agricultural or forestry operations)
- A1: Reuse of products or materials from a previous product system
- A1: Processing of secondary materials used as input for manufacturing the product, but not including those processes that are part of the waste processing in the previous product system
- A1: Generation of electricity, steam and heat from primary energy resources, including extraction, refining and transport thereof
- A1: Energy recovery and other recovery processes from secondary fuels, but not including those processes that are part of waste processing in the previous product system
- A2: Transportation up to the factory gate in addition to internal transport
- A3: Production of ancillary materials or pre-products

- A3: Manufacturing of packaging
- A1-A3: Processing up to the end-of-waste state or disposal of final residues including any packaging not leaving the factory gate with the product.

The impacts have been inventoried for the following data categories:

- energy inputs
- material inputs
- emissions to air, water and soil
- production of waste and treatment
- produced products

The abovementioned flows are called data categories. They define the scope of the inventory.

A description of the most important modeling parameters is included below.

Raw Materials

The lavatory raw materials have been majorly grouped into three categories: body slip and glaze (ceramic materials), casting materials, and installation parts.

Ceramic constitutes the body of the lavatory and inputs to the system are body slip and glaze. The recipe of raw materials for the body slip and glaze for the different ceramic products manufactured in TMX including the transportation mode and distances when purchased are comprised of the following:

Table 6.5.1a TOTO Mexico ceramic slip materials used 2013 (confidential)

Constituent/material type	Percentage of materials	Transportation mode	Distance (km)
		Truck and trailer	
		Truck and trailer	
		Truck and trailer	
		Truck and trailer	
		Truck and trailer	
		Truck and trailer	

Table 6.5.1b TOTO Mexico ceramic glaze materials used 2013

Constituent/material type	Percentage of materials	Transportation mode	Distance (km)
		Truck and trailer	
		Truck and trailer	
		Truck and trailer	
		Truck and trailer	
		Truck and trailer	
		Truck and trailer	
		Truck and trailer	
		Truck and trailer	
		Truck and trailer	
		Truck and trailer	
		Truck and trailer	
		Truck and trailer	

Non-ceramic parts that make a lavatory are installation parts. All parts with a weight of >1% weight of the parts (excluding ceramic and packaging materials) are included in the LCA model. We assume a yield loss of 10% for the metals that make up the installation parts. Table 6.5.1c shows an aggregation of materials that make up the non-ceramic parts of the product. A check has been performed to make sure that the completeness of the overall material use is >99.0%wt. of the finished product after cut-off and including the ceramic and packaging materials. The specific numbers of completeness are listed in Table 6.5.1d.

Table 6.5.1c Installation parts constituent

Constituent	LT307(A)	LT569
Lead	0.00%	21.15%
Stainless Steel	100%	78.85%

Table 6.5.1d Completeness of the parts after 1% weight cut-off of the non-ceramic parts

Product code	%wt covered
LT307(A)	99.96%
LT569	99.98%

Because data on recycled content was not provided, it was assumed that only primary materials were used and included in the model accordingly. This is typically a worst-case scenario which would require an effort to improve future LCA modeling results. A more detailed raw materials definition of the products is presented in Appendix A (Tables A.1 and A.2). No primary data of unit processes except for the ceramic manufacturing was used in the model. The generic data used for processing are presented in Appendix A (Tables A.3 and A.4). Default allocations of ecoinvent datasets are assumed to apply in this model. A table of data assessment is provided in section 7.3.

Manufacturing

The lavatories at the TMX plant are manufactured as follows:

- Raw materials arrive by truck and are unloaded / stored into silos or designated area.
- The preparation materials, primarily materials that embody the mass of the lavatory, are batched into two different clay slurries called *slip;* the first is *casting slip* and the second is *glazing slip*.
- The casting slip is pumped into plaster molds and a portion of the water diffuses out of the slip and into the plaster mold, producing the ceramic pieces. These pieces are then de-molded and sent to the dryer.
- The dry product is inspected. Minor defects can often be repaired prior to glazing; however, products with irreparable defects are recycled back into casting slip and placed into the system. Products that pass inspection are then sprayed with glaze. The water in the glaze absorbs into the dry body and leaves a powder coat of glaze.
- The glazed product is fired in a process called *vitrification* during which organic components in the raw materials are burned out to form CO_2, NO_x, and SO_x and released with exhaust gas stream through wet scrubber to the atmosphere. During vitrification, the pores close up. The glassy raw materials melt and make the body solid and impermeable, and the same materials in the glaze make the surface shiny and hard.
- The fired product is inspected. Products that pass inspection have the fixtures installed, and are boxed. Products with defects are repaired and re-fired if possible. Products with irreparable defects are recycled as raw material for construction materials.
- Finished products are boxed and shipped to TOTO distribution centers in the U.S.

The process flow for the TOTO Mexico production stage is represented in Figure 6.5.1a. A process flow from the TOTO USA Morrow facility (Figure 6.5.1b) has been included for clarity and for the purposes of comparison, as the processes are very similar.

Figure 6.5.1a TOTO Mexico Manufacturing Process (confidential)

Figure 6.5.1b TOTO USA Morrow Manufacturing Process (confidential)

Mass Balance reconciliation

In order to allocate manufacturing data to the product modeled, it is necessary to have an insight into the number of ceramic products produced in the considered facilities as well as the yield percent of the plants. *Yield* is a composite of production losses at the different stages of the manufacturing process. *Product yield* percentage is the percentage of final product compared to the raw materials input; while *total plant yield* is the average yield percentage for all the products manufactured in the plant. Differences in yield percentages are due to complexity of the products produced and differences in applied processes (for example, casting method).

A summary of the mass balance calculations for the TMX facility in 2013 is provided below in Table 6.5.1e. Individual inputs and outputs can be viewed in Appendix A.

Table 6.5.1e TOTO Mexico mass balance calculation in 2013 (confidential)

Raw materials	kg	
Raw materials (excluding loss of ignition)	kg	
Total In	kg	
Product Weight	kg	
Product Waste	kg	
Total Out	kg	
Mass balance (in / out; %wt.)		

Total energy consumption and emissions in the plant are allocated to different products based on the *production efficiency*. *Production efficiency* is the efficiency of energy input embedded in the product and emissions out from the production. Energy input and emission output would firstly be reported in average at the plant level while the product specific data would be reported later for each product. All processes are assigned to the final product based on the yields presented in Table 6.5.1f & g using the total yield and production efficiency, with the exception of natural gas use and associated emissions from the kiln. Natural gas usage and associated emissions are allocated by using the firing yield. In order to assign inputs and outputs to different products, all the data reported below are based on data per weight of ceramics.

For the most part, the casting materials are process aids. Exceptions are soluble salts majorly within the bonding slip, which are applied to the lavatory during casting and do remain as part of the body. However, compared to the rest of the ceramic part, bonding slip is less than 0.02% of total weight.

Table 6.5.1f Total yield percentage for TOTO Mexico (confidential)

Overall Plant Yield 2013	
TMX	

Table 6.5.1g Yield percentage and production efficiency for ceramic products (confidential)

Product Yield			
Product code	**Total yield percentage**	**Average Production efficiency**	**Firing yield**
LT307(A)			
LT569			

The loss of ignition is an important factor that influences the mass balance. Because water content, crystal water, and organic material in the raw materials are eliminated during the firing process, the ceramic loses mass. Loss of ignition is a good measure for these mass losses. This factor is included in calculating the overall mass balance and is presented in the table below.

Table 6.5.1h Loss of ignition in 2013 (confidential)

Loss of Ignition

TMX	

In order to assign inputs and outputs to products, all the data reported below are based on data per weight of ceramics.

Energy Requirements

The major manufacturing processes were described earlier in this section. Table 6.5.1i below provides the energy requirement to produce one kg of ceramic in TMX.

Table 6.5.1i Energy usage for ceramic manufacturing in 2013 (confidential)

Energy Source	Unit	TMX
Electricity from grid	kWh/kg	
Natural gas	Cu.ft./kg	

Electricity for TMX is modeled after the Mexican grid mix using ecoinvent data. In the manufacturing process, drying takes 30-35 hours, at 140 degrees Fahrenheit (60 degrees Celsius). Firing takes 12-18 hours, with the hottest temperature at 2,200 degrees Fahrenheit (1,200 degrees Celsius). TMX has a new kiln of approximately 8 years and is very efficient due to its newer construction.

Water consumption

The manufacturing operation requires the consumption of water. In 2013, TOTO Mexico consumed approximately 4.94 liters per kg of ceramic. Table 6.5.1j shows the amount of water per kilogram of ceramic used in each plant.

Table 6.5.1j Water usage per kilogram of ceramic (confidential)

Water usage TMX	
Liters per kg ceramic	

All water waste is processed on-site in the wastewater treatment plant (WWTP). Treatment utilizes flocculants which were included in the analysis and modeling. Much of the greywater from this process is reused in the plant. The remainder of water is discharged to the respective city or county water systems via the public sewer system.

Despite the relatively high water usage, TOTO Mexico's operations attempt to reduce the use of natural resources. For example, over 6,000 gallons of on-site recycled greywater per day is reused in the plant. The remainder of water is treated and discharged to the public sewer system.

Environmental outputs

The major air emission during manufacturing from materials is carbon dioxide, coming from natural gas combustion as well as through carbonate decomposition and organic combustion of raw materials during the firing process. Because the drying and firing temperature is high enough for carbonation, we assume that the worst case scenario that all possible raw materials are carbonated and combusted during the process, amounting to approximately (confidential) metric tons in TMX, 1.1% compared to CO_2 emissions from natural gas.

Table 6.5.1k Air emissions from TOTO Mexico in 2013 (confidential)

Air emission	Grams per kg of ceramic
NO_x	
SO_2	
CO	
CO_2	

TOTO Mexico's wastewater treatment plant treats all wastewater before it is returned to the city or county water authority. Discharged water is tested for various effluents in accordance with local ordinances. Wastewater emissions are listed in table 6.5.1l below:

Table 6.5.1l Water effluents for manufacturing in 2013 (confidential)

Water effluents	Grams per kg ceramic
Chemical Oxygen Demand	
Total Kjeldahl Nitrogen (TKN)	
Phosphorous matter	
Aluminum	
Copper	
Zinc	
NO3-NO2	
Total Suspended Solids	
Biochemical Oxygen Demand	
Chloroform	
Bis(2-ethylhexyl)phthalate	
Grease & Oil	
Antimony	
Beryllium	
Cadmium	
Chromium	
Lead	

Other materials: parts and packaging

Finished products from TMX are packaged in carton boxes, some of which contain a top and bottom pad, along with some inserts and stickers. After packing, boxes are stapled, palletized and wrapped with stretch wrap. The finished product is ready for transportation to US distribution centers and ultimately to the US market. The stretch wrap is below the cut-off of 1%wt and impacts. The pallets are included in the analysis and modeling based on purchasing data per facility. They are purchased in sizes of 48x48 and 54x48, with an average weight of 31.5lb per unit by engineers manual weighing. In 2013, TMX purchased (confidential) pallets. Packaging includes corrugated board, stickers, and paper. The corrugated board that makes up the boxes, pads, and inserts are included for each product and assumed to contain no recycled content. Stickers and paper equal to or greater than 1% of total weight are included. Packaging is listed below in Table 6.5.1m.

Table 6.5.1m Packaging information

Product code	Cardboard (kg)	Paper (kg)

LT307(A)	1.02	0.031
LT569	1.71	0.054

Transportation

Transportation distances of the raw materials and processing aids were provided by TMX. Trucks and ocean freighters are assumed to be diesel-powered. No empty returns are accounted for in truck and trailer transportation. All materials are transported by truck and trailer and are from the Monterrey metropolitan area, with the exception of dolomite, which has a transportation distance of 150 km.

Solid waste

Solid waste from TMX includes sludge, ceramic scrap, mold scrap, carton boxes, metal scrap and other wastes. Ceramic scrap and mold scrap are sent to a cement company for use as a raw material. Other materials, such as plastics and corrugated board packaging, are sent to off-site recycling facilities. All the wastes and their weight as well as their fate in TMX are listed below. Sludge, also known as filter cake, refers to the slip and glaze solids removed during the wastewater treatment process. We assume the water content percentage of sludge for TMX to be the same as TOTO USA, as verification data was not available. TOTO USA sludge contains approximately 30-40% water, as measured by samples taken from the Morrow plant. The percent water weight of sludge is not routinely monitored; however, wastewater specialists have measured the content in the past and observed the process every day. They confirmed that the consistency is constant due to the efficiency of the press.

Transportation of solid wastes to the sites to treat is included in the model as seen in Table 6.5.1n below. We assumed that all the solid wastes are conveyed by diesel-powered trucks.

Table 6.5.1n Waste from TMX in 2013 (confidential)

Solid waste (g per kg of ceramic)	**TMX**		
	Weight	**Fate**	**Distance**
Sludge			
Wasted gypsum			
Ceramic scrap			
Pallet scrap			
Carton scrap			
Metal scrap			
Waste plastic containers			

6.5.2. A4-A5, Construction stage, Information modules

The construction process stage includes the following information modules:

- A4: Transport to the building site
- A5: Construction / installation in the building

Transportation to site

Products are packaged in the manufacturing plant and are shipped directly to TOTO owned distribution centers in the US. The two distribution centers are the Fairburn Assembly Plant (FAP), located in Fairburn, GA (east distribution center, EDC) and the Ontario Assembly Plant (OAP), located in Ontario, CA (west distribution center, WDC). Approximately 70% of manufactured product goes to FAP and 30% to OAP, depending on the regional demand of certain products. Transportation distances and modes from TMX to distribution centers are listed in Table 6.5.2. The lavatories arrive finished and require no further assembly.

Table 6.5.2 Transportation distance and mode from TMX to US distribution centers (confidential)

Transport to West OAP (km)			**Transport to East FAP (km)**		
Oceanic	Rail	Truck and trailer	Oceanic	Rail	Truck and trailer

After products are purchased by distributers, dealers, and showrooms for purchase by the end users, they are transported from the FAP or OAP warehouse to these purchasers. Transportation and distance would vary and are dependent on the locations of the purchasers and shipping mode. Outbound shipments to customers travel via rail and/or diesel truck. In 2013, outbound shipments were transported an average of (confidential) miles by diesel truck and an average of (confidential) miles by rail. When factoring the quantity transported by truck and rail (83% and 17% respectively), the weighted average transported distance comes to approximately (confidential) miles. TOTO sourcing data is based on actual 2013 shipment averages. All transportation LCI data comes from the U.S. LCI database.

Construction / Installation

After customers purchase the products from distribution centers, they are installed. Installation into the builing is assumed to be manual or negligble in terms of energy consumption. Other than packaging, which is mainly compromised of cartons, becoming waste, nothing else is required or removed at this stage. Waste processing of the waste from product packaging up to the end-of-waste state or disposal of final residues is included in this module.

6.5.3. B1-B5, Use stage information modules related to the basic fabric

The basic use stage includes the following information modules:

- B1: Use or application of the installed product
- B2: Maintenance
- B3: Repair
- B4: Replacement
- B5: Refurbishment

Use or application of the installed product

There are no additional activities or construction work needed or associated with the installation of the product during the use phase. Therefore, this module's LCIA is considered to be zero.

Maintenance

Maintenance of the lavatory would include regular cleaning. The assumption is that daily cleanings occur, with a solution comprised of 10% sodium lauryl sulfate (SLS), resulting in 73 kg of SLS over the duration of the 20 year life span. A table of the calculation is presented below in Table 6.5.3 and has been included in the model.

Table 6.5.3 Calculation of cleaning solution used in the use phase

Cleaning Spec	(L)/Use	Time Span for Model (year)	Total Number of Uses	Total Consumption for Life (L)
10 mL 1% SLS/day	0.01	20	7,300	73.00

Repair

The service life is defined in such a way that for a typical installation, no repair is required. Repair would be incidental. There is no repair included in the model, as this module's LCIA is considered to be zero.

Replacement

The service life is defined in such a way that for a typical installation, replacing a whole product in order to return product to a condition in which it can perform its required functional or technical performance is not required. Replacements are not relevant and therefore no calculation rules need to be defined. The model does not include replacements, therefore this module's LCIA is considered to be zero.

Refurbishment

The service life is defined in such a way that for a typical installation, no refurbishment is required. There is no refurbishment included in the model, as this module's LCIA is considered to be zero.

6.5.4. B6-B7, Use stage information modules relating to the operation of the building

The use stage relating to building operation includes the following information modules:

- B6-B7: Operational energy and water use

Operational energy and water use

The service life is defined in such a way that no operational energy and water use is applied. Operational energy and water use is assigned to the faucet used in combination with the lavatory.

6.5.5. C1-C4, End-of-life stage information modules

The end-of-life stage includes:

- C1: Deconstruction / demolition
- C2: Transport to waste processing
- C3: Waste processing for reuse, recovery and/or recycling
- C4: Disposal

The lavatories are assumed to have a useful life of beyond 20 years. At the end of life, it is assumed that the lavatories are landfilled but their installation parts follow the waste scenarios as outlined in Table 6.5.5. TOTO ceramic materials can be recycled as aggregate in several applications; however this is not a common practice at the moment. According to the data from the U.S. EPA's Municipal Solid Waste Generation, Recycling, and Disposal in the United States Report for 2010[1], 62.5% of paper and paperboard, 33.8% of the steel, and 70.50% of other non-ferrous metals in municipal wastes are recycled. We use these rates to define the waste scenario of metal and plastic parts in the toilets.

Table 6.5.5 List of waste scenarios for materials

Material	Waste scenario	
	Recycling	Landfill
Brass, Zinc	70.5%	29.5%
Ceramic	0.00%	100%
Corrugated board, Paper	62.5%	37.5%
Steel	33.8%	76.2%

De-construction / demolition stage

At the end of life, de-construction of the products which include their dismantling as well as the initial on-site sorting is assumed to be manual or negligble in terms of energy consumption. No deconstruction activities were included in the model, as this module's LCIA is considered to be zero.

Transport to waste processing stage

The transport stage involves the transportation of the discarded products to waste processing either to recycling or to final disposal. The transport stage included in the model is based on the assumption that the product will travel 100 km on a truck either to a landfill as a final disposal or to a recycling site.

Waste Processing stage

The waste processing of material flows transported to a recycling site following the waste scenarios of materials as listed in Table 6.5.5 were assumed to be intended for recycling and were included in the model. All processing including pre-sorting, crushing, and shredding were modeled.

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[1] United States Environmental Protection Agency, Municipal Solid Waste Generation, Recycling, and Disposal in the United States: Facts and Figures for 2010. http://www.epa.gov/osw/nonhaz/municipal/pubs/msw_2010_factsheet.pdf.

Disposal stage

The disposal of material flows transported to a landfill following the waste scenarios of materials as listed in Table 6.5.5 were included in the model.

6.5.6. Benefits and loads beyond the product system boundary, information module D

Module D reports the environmental benefits or loads resulting from net flows of reusable products, recyclable materials and/or useful energy carriers leaving a product system (e.g. as secondary materials or fuels). It includes recycling potentials of materials expressed as net impacts and benefits. All recycled materials as shown in Table 6.5.5 are processed in the waste processing stage (i.e. Module [C3]). It was assumed that on average a yield of 90% substitutes that amount of primary material (Table 6.5.6). There is no thermal recovery modeled for end of life as is defined in the scenarios in Table 6.5.6.

Table 6.5.6 Substitution in recovery stage

Material	% of substitution	Substitute Material
Cardboard, primary	90%	Sulphate pulp
Lead	90%	Brass
Stainless steel	90%	Steel

6.5.7. Power mix

Manufacturing electricity is modeled using Mexico specific grid mix based on ecoinvent 2.0 definitions. No US-specific or any other country-specific energy is included in the product module [A1-A3]. No green energy was included in the model. When transforming the inputs and outputs of combustible material into inputs and outputs of energy, the lower caloric value specific to the material have been applied based on scientifically accepted values.

6.5.8. CO_2 certificates

CO_2 credits were not included in this assessment.

6.5.9. Description of the system boundary in the project report

The system boundaries for TOTO ceramic products are detailed below. Figure 6.5.9 represents the life cycle phases and stages for the entire life cycle of these products. Declared modules are indicated by the presence of an “X”. The LCA scope is cradle-to-grave, and so therefore all modules have been declared and no module omissions have been made. A list of assumptions and exclusions is provided in this section of the report. The analysis period of all modules is the calendar year 2013.

	Product assessment information																
	Product life cycle information																Supplementary information (benefits and loads) beyond the product life cycle
Transparency Report aggregated modules	Production			Construction		Use							End of life				Recovery
	A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
Transparency Reports system boundary	Raw Materials	Transport	Manufacturing	Transport	Construction / installation stage	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-construction demolition	Transport	Waste processing	Disposal	Reuse- Recovery- Recycling- potential
Cradle-to-grave Functional unit	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

X = a declared module

Figure 6.5.9 Applied system boundaries for the modeled ceramic products

Major assumptions and exclusions associated with system boundaries:

A1-A3

- We assume empty returns for raw material transportation – diesel
- We assume raw materials are virgin materials (metal parts and packaging)
- We assume yield percentages for metals of installation parts
- Casting and firing process aids are omitted due to cut-off criteria
- Generic data is used for metal parts and packaging
- Materials used for the rework of defective product are omitted
- Stretch wrap and staples are omitted
- A1-A3 waste processing is assumed per EPA statistics
- Recovery yields of scrap ceramic and gypsum recycling are assumed
- Water content of sludge is assumed based upon processes at TOTO USA
- We assume a distribution rate of 70% and 30% for the EDC and WDC, respectively
- Some packaging materials (such as stickers and plastic bags) are omitted due to cut-off criteria
- The electricity dataset is a country-specific production mix and is based on generic data from 2007

A4-A5, Construction stage, Information modules

- Outbound shipments are calculated for all TOTO USA sales and not specific to the modeled products
- We assume no or negligible energy consumption for construction
- Fuel economies for transport are assumed by the dataset

B1-B5, Use stage information modules related to the basic fabric

- Sodium lauryl sulfate usage is assumed for the maintenance phase

C1-C4, End-of-life stage information modules

- We assume no or negligible energy consumption for demolition
- We assume all ceramic is sent to landfill
- We assume a 90% recovery yield
- Transport to waste processing is assumed to be 100km using deisel fuel
- Recycling vs landfill rates are assumed per EPA statistics

All modules

- Dataset accuracy and representativeness can affect the reliablity of results

6.6 Criteria for the exclusion of inputs and outputs

The time period over which inputs to and outputs from the system are accounted for is 100 years from the year for which the data set is deemed representative.

The cut-off criteria on a unit process level can be summarized as follows:

- *Mass* – If a flow is less than 1% of the cumulative mass of the model it may be excluded, providing its environmental relevance is not a concern.
- *Energy* – If a flow is less than 1% of the cumulative energy of the model it may be excluded, providing its environmental relevance is not a concern.
- *Environmental relevance* – If a flow meets the above criteria for exclusion, yet is thought to potentially have a significant environmental impact, it is included. Material flows which leave the system (emissions) and whose environmental impact is greater than 1% of the whole impact of an impact category that has been considered in the assessment have been covered. This judgment is done based on experience and documented as necessary, but also relies on the used literature data.
- The sum of the neglected material flows does not exceed 5% of mass, energy or environmental relevance for flows indirectly related to the process (e.g. operating materials).

In this report, all flows for the primary manufacturing data for TOTO Mexico that fall within the cut-off criteria have been reported. The completeness of the bill of materials for the products is reported in the previous chapter (section 6.5.1) and satisfies the above defined cut-off criteria. Some plant specific data were not used as they were incomplete or hard to verify. When this occurred, assumptions were made according to manufacturing for TOTO USA. An example of this is the water content of sludge. A list of additional assumptions is included in section 6.5.9. The significance of plant data on LCA results will show up in future LCA studies as TOTO continues to collect more LCA-relevant data. Some examples of excluded flows are listed below:

Casting process aids: These include soluble salts within the bonding slip. These materials are applied to the lavatory during manufacturing and do remain as part of the body; however, compared to the rest of the ceramic part, these materials account for less than 0.02% of total weight of the product.

Firing process aids: These include logo inks and, when necessary, materials for rework. These materials are applied to the lavatory during manufacturing and do remain as part of the body; however, compared to the rest of the ceramic part, these materials account for less than 0.01% of total weight of the product.

Miscellaneous packaging: Stretch wrap, stickers, polyethylene bags and staples are excluded because they account for less than 0.01% of the total weight of the product.

Installation/demolition energy: Installation requires affixing the lavatories to the wall for LT307(A) and under the counter for LT569. This requires the use of installation hardware. Hardware is installed either manually or with power tools. The energy consumption of a power tool in installing a lavatory is negligible.

7 LIFE CYCLE INVENTORY ANALYSIS

7.1 Collecting data and calculation procedures

Most of the manufacturing data came from primary sources for the calendar year 2013. TOTO Mexico Production Engineers collected all data using electric bills, purchasing orders, production volume, data on waste and damaged final products, and production yield and efficiency. Where data was missing, assumptions were made based on data and knowledge regarding TOTO USA’s manufacturing facilities. A list of relevant assumptions is provided in section 6.5.9. Production experts made these assumptions based on their expertise in certain areas. The lead LCA practitioner and TOTO’s project manager worked together from day one on collecting data and undergoing a data validation process using mass balances and other calculation methods. No materials, components, emissions or energy flows have been left out, except for minor parts where the primary sources’ data was incomplete or contradictory to the average industry data. This follows the general rule that either specific data or average data derived from specific production processes shall be the first choice as outlined in Part A. When transforming the inputs and outputs of combustible material into inputs and outputs of energy, the lower caloric values specific to the materials have been applied based on scientifically accepted values.

7.2 Developing product level scenarios

All modules were included in the LCA and described in section 6.5. The product stage consists of primary data from manufacturing; however, the modules that are scenario-based are presented and summarized below. A list of assumptions associated with these modules has been provided in section 6.5.9. Additional details, including calculations, are provided in the description of the life cycle stages in section 6.5.

A4-A5, Construction stage, Information modules

Table 7.2a presents transport to the building site within the construction phase. These values were derived from 2013 shipment data compiled by the TOTO logistics department. Table 7.2b presents inputs associated with installation into the building.

Installation into the building is assumed to be manual or negligble in terms of energy consumption. After installation, the cardboard packaging is disposed.

Table 7.2a Transport to the building site [A4] (confidential)

Name	Value	Unit
Liters of fuel		l/100km
Transport distance		km
Capacity utilization (including empty runs)	-	%
Gross density of products transported	-	kg/m3
Capacity utilization volume factor	-	%

Table 7.2b Installation into the building [A5]

Name	LT307(A) Value	LT569 Value	Unit
Auxiliary	-	-	kg
Water consumption	-	-	m3
Other resources	-	-	kg
Electricity consumption	-	-	kWh
Other energy carriers	-	-	MJ
Material loss	-	-	kg
Output substances following waste treatment on site (cardboard packaging) per lavatory	1.75	1.08	kg
Dust in the air	-	-	kg
VOC in the air	-	-	kg

B1-B5, Use stage information modules related to the basic fabric

The reference service life for lavatories is 20 years. It is assumed that lavatories are cleaned daily with a solution comprised of 10% sodium lauryl sulfate (SLS). The service life is defined in such a way that repair, refurbishment, or replacement of lavatories does not occur within the 20 year lifespan. Tables 7.2c through 7.2f present data associated with modules B1-B5.

Table 7.2c Use phase reference [B1]

Name	Value	Unit
Flushes/day/person	N/A	-
Reference service life (RSL)	20	years

Table 7.2d Maintenance [B2]

Name	Value	Unit
Information on maintenance	-	-
Maintenance cycle	7300	Number/RSL
Water consumption	-	m3
Auxiliary	-	kg

Other resources	73	kg
Electricity consumption	-	kWh
Other energy carriers	-	MJ
Material loss	-	kg

Table 7.2e Repair [B3]

Name	**Value**	**Unit**
Information on the repair process	-	-
Information on the inspection process	-	-
Repair cycle	-	Number/RSL
Water consumption	-	m3
Auxiliary	-	kg
Other resources	-	kg
Electricity consumption	-	kWh
Other energy carriers	-	MJ
Material loss	-	kg

Table 7.2f Replacement [B4] / Refurbishment [B5]

Name	**Value**	**Unit**
Replacement cycle	-	Number/RSL
Electricity consumption	-	kWh
Litres of fuel	-	l/100km
Replacement of worn parts	-	kg

B6-B7, Use stage information modules relating to the operation of the building

Lavatories serve as a vessel for flowing water; therefore, energy and water use is assigned to the faucet for which the lavatories are coupled. The B6-B7 module is presented in table 7.2g.

Table 7.2g Operational energy use [B6] and Operational water use [B7]

Name	**Value**	**Unit**
Water consumption	0	m3
Electricity consumption	-	kWh
Other energy carriers	-	MJ
Equipment output	-	kW

C1-C4, End-of-life stage information modules

Deconstruction/demolition of the lavatory is assumed to be manual or to have negligible energy and resource use. At the end-of-life, the ceramic portion of the lavatory is assumed to be sent to a landfill. A percentage of the metal parts is assumed to be recycled, and the remainder sent to landfill. Percentage of recycling to landfilling of metal parts follows published EPA data for 2010[2]. Table 7.2h presents data associated with the end-of-life stage.

Table 7.2h End of life [C1-C4]

Name	LT307(A) Value	LT569 Value	Unit
Collected separately	2.10	1.21	kg
Collected as mixed construction waste	16.6	7.00	kg
Reuse	-	-	kg
Recycling	1.20	0.690	kg
Energy recovery	-	-	kg
Landfilling	17.5	7.52	kg

7.3 Selecting data/background data

The materials are modeled with facility data from TMX. TMX was contacted using standardized questionnaires, and answers were pulled from bills and manufacturing documentation by manufacturing engineers in the facilities and provided to TOTO USA. Data validation/verification was done using the expertise of engineers with information on processes, oven's age and efficiency, machines' power ratings, sites' conditions and labor force, electricity consumptions, yield and production efficiency information, production rates, and mass balances. Where data is missing or where gaps existed, assumptions from the TOTO USA facilities have been utilized. An overview of used data sources is presented in Appendix A.

Some data was confidential and is therefore not included in this report, but has been part of a review by Sustainable Minds. We have used publicly available data on composition and manufacturing for upstream and missing data and have supplemented that with literature data that is representative for the products.

All used primary data reflects data for the calendar year 2013, with regional specific data. All used background data to model the LCA is reported in Appendices A and D. Literature data comprises of the best available data from consistent sources, but varies from material to material in geographical, time related and technology coverage due to limited availability of specific data. Data from the US ecoinvent database was aimed to be used mostly. However, this does not warrant full consistency between all data sets. Different data can result in differences per material and that can influence the comparison. By using the US ecoinvent data the report follows the data quality in these datasets as it relates to time period coverage. The main criterion for data selection was the technological coverage as to reflect the physical reality of the declared product or product group as close as possible. Tables presenting the technological, geographical and time related representativeness of the data used are provided in section 7.4.

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[2] United States Environmental Protection Agency, Municipal Solid Waste Generation, Recycling, and Disposal in the United States: Facts and Figures for 2010. http://www.epa.gov/osw/nonhaz/municipal/pubs/msw_2010_factsheet.pdf.

7.4 Data/background data quality requirements

Data quality is important in arriving at reliable results that properly inform decisions related to LCA studies. Technological, geographical and time related representativeness for the data used are documented in the tables below. Input process flows are provided with details regarding the data used. Table 7.4a presents information on data used to model LT307(A). Table 7.4b presents information on data used to model LT569. The tables are also referenced in Appendix D.

Table 7.4a Data sources and quality assessment for the model of LT307

Module	**Process/material**	**Description**	**Source**	**Data Quality***						**Year and representativeness**
				R	**C**	**T**	**G**	**F**	**S**	
[A1-A3]	Ceramic	Energy, raw materials, emissions and waste for TOTO Mexico ceramic production	All TOTO Mexico manufacturing data comes from primary data sources for the year 2013	1	1	1	1	1	1	2013; specific
	Cardboard	Manufacturing at suppliers	Data taken from ecoinvent 2.0 for corrugated board in the US	1	2	3	2	1	na	2007; generic
	Steel	Manufacturing at suppliers	Data taken from ecoinvent 2.0 for stainless steel production and ecoinvent 2.2 for steel stamping in the US	1	1	3	2	2	na	2007; generic
	Paper	Manufacturing at suppliers	Data taken from ecoinvent 2.0 for paper in the US	1	1	4	2	1	na	2003; generic
	Transport by truck	Transportation to manufacturer: Truck fuel mix is based on country-specific fuel mix and it is assumed that all products come from the Monterrey metropolitan area, with the exception of dolomite, which has a transportation distance of 150 km.	The truck fuel mix is based on a US fuel mix. The assumption is that all materials are supplied from the Monterrey metropolitan area, with the exception of dolomite, which has a transportation distance of 150 km.	1	1	3	2	2	na	2008; generic
	Electricity		Mexico-specific electricity data from ecoinvent 2.0	1	1	3	1	2	na	2007; generic
	Natural gas		Data taken from ecoinvent 2.0 for US natural gas	1	1	4	2	1	na	2003; generic
[A4]	Transport by truck	Transportation is calculated based on US average fuel mix in a combination truck.	Information on distance and mode to site comes from primary data sources. The truck fuel mix is based on a US fuel mix from ecoinvent 2.2	1	1	3	2	2	na	2008; generic
	Transport by rail	Transportation is calculated based on US diesel in a train.	Information distance and mode to site comes from primary data sources. The train fuel mix is based on a US diesel mix from ecoinvent 2.2	1	1	3	2	2	na	2008; generic
[A5]	Installation	Landfill of packaging cardboard and paper	Cardboard and paper landfilling for the US were modeled using ecoinvent 2.2 data. Percentages of landfill are based on EPA data.	1	1	4	1	2	na	2003; generic

		Recycling of packaging cardboard and paper	Cardboard and paper recycling for the US were modeled using ecoinvent 3.0 data. Percentages of recycling are based on EPA data.	1	1	1	1	2	na	2014; generic
[B2]	Maintenance	Regular cleaning of the lavatory with a 10% sodium lauryl sulfate solution based on a 20 year RSL	Data taken from ecoinvent 2.2 for a sodium lauryl sulfate proxy based on a 20 year RSL in the US.	1	1	4	2	2	na	2003; generic
[C2]	Transport by truck	Transportation to recycle or landfill site is calculated based on US average fuel mix in a combination truck.	Transportation to the site is based on the assumption that the product will travel 100 km on a truck. The truck fuel mix is based on a US fuel mix from ecoinvent 2.2	1	1	3	1	2	na	2008; generic
[C3]	Waste processing	Recycling of steel	Steel recycling in the US modeled using ecoinvent 3.0 data with a 90% recovery rate in module D. Percentages for recycling are based on EPA recycling data.	1	2	3	1	2	na	2007; generic
[C4]	Disposal	Landfill of ceramic	Inert material landfill in the US modeled using ecoinvent 2.2	1	1	4	1	2	na	2003; generic
		Landfill of steel	Steel landfill in the US modeled using ecoinvent 2.2 data with a 90% recovery rate in module D. The percentage of steel sent to landfill is based on EPA data.	1	1	4	1	2	na	2003; generic
[D]	Recovery	Recovery	Energy recovery and recycling potential from steel as described above.	See above						See above
*Data quality: **R** Reliability; **C** Completeness; **T** Temporal correlation; **G** Geographical correlation; **F** Further technological correlation; **S** Sample size; 1 is highest, 5 is lowest										

Table 7.4b Data sources and quality assessment on the model of LT569

Module	Process/material	Description	Source	Data Quality*						Year and representativeness
				R	C	T	G	F	S	
[A1-A3]	Ceramic	Energy, raw materials, emissions and waste for TOTO Mexico ceramic production	All TOTO Mexico manufacturing data comes from primary data sources for the year 2013	1	1	1	1	1	1	2013; specific
	Cardboard	Manufacturing at suppliers	Data taken from ecoinvent 2.0 for corrugated board in the US	1	2	3	2	1	na	2007; generic
	Steel	Manufacturing at suppliers	Data taken from ecoinvent 2.0 for stainless steel production and ecoinvent 2.2 for steel stamping in the US	1	1	3	2	2	na	2007; generic
	Lead	Manufacturing at suppliers	Data taken from ecoinvent 2.2 for lead and injection molding in the US	1	1	4	3	3	na	2003; generic
	Paper	Manufacturing at suppliers	Data taken from ecoinvent 2.0 for paper in the US	1	1	4	2	1	na	2003; generic

	Transport by truck	Transportation to manufacturer: Truck fuel mix is based on country-specific fuel mix and it is assumed that all products come from the Monterrey metropolitan area, with the exception of dolomite, which has a transportation distance of 150 km.	The truck fuel mix is based on a US fuel mix. The assumption is that all materials are supplied from the Monterrey metropolitan area, with the exception of dolomite, which has a transportation distance of 150 km.	1	1	3	2	2	na	2008; generic
	Electricity		Country-specific electricity data from ecoinvent 2.0	1	1	3	1	2	na	2007; generic
	Natural gas		Data taken from ecoinvent 2.0 for US natural gas	1	1	4	2	1	na	2003; generic
[A4]	Transport by truck	Transportation is calculated based on US average fuel mix in a combination truck.	Information on distance and mode to site comes from primary data sources. The truck fuel mix is based on a US fuel mix from ecoinvent 2.2	1	1	3	2	2	na	2008; generic
	Transport by rail	Transportation is calculated based on US diesel in a train.	Information distance and mode to site comes from primary data sources. The train fuel mix is based on a US diesel mix from ecoinvent 2.2	1	1	3	2	2	na	2008; generic
[A5]	Installation	Landfill of packaging cardboard and paper	Cardboard and paper landfilling for the US were modeled using ecoinvent 2.2 data. Percentages of landfill are based on EPA data.	1	1	4	1	2	na	2003; generic
		Recycling of packaging cardboard and paper	Cardboard and paper recycling for the US were modeled using ecoinvent 3.0 data. Percentages of recycling are based on EPA data.	1	1	1	1	2	na	2014; generic
[B2]	Maintenance	Regular cleaning of the lavatory with a 10% sodium lauryl sulfate solution based on a 20 year RSL	Data taken from ecoinvent 2.2 for a sodium lauryl sulfate proxy based on a 20 year RSL in the US.	1	1	4	2	2	na	2003; generic
[C2]	Transport by truck	Transportation to recycle or landfill site is calculated based on US average fuel mix in a combination truck.	Transportation to the site is based on the assumption that the product will travel 100 km on a truck. The truck fuel mix is based on a US fuel mix from ecoinvent 2.2	1	1	3	1	2	na	2008; generic
[C3]	Waste processing	Recycling of steel	Steel recycling in the US modeled using ecoinvent 3.0 data with a 90% recovery rate in module D. Percentages for recycling are based on EPA recycling data.	1	2	3	1	2	na	2007; generic
		Recycling of lead	Lead recycling in the US modeled with non-ferro material substitution using ecoinvent 2.2 data with a 90% recovery rate in module D. Percentages for recycling are based on EPA recycling data.	1	1	3	3	2	na	2007; generic
[C4]	Disposal	Landfill of ceramic	Inert material landfill in the US modeled using ecoinvent 2.2	1	1	4	1	2	na	2003; generic

		Landfill of steel	Steel landfill in the US modeled using ecoinvent 2.2 data with a 90% recovery rate in module D. The percentage of steel sent to landfill is based on EPA data.	1	1	4	1	2	na	2003; generic
		Landfill of lead	Lead landfill in the US modeled using ecoinvent 2.2 data with a 90% recovery rate in module D. The percentage of lead sent to landfill is based on EPA data.	1	1	4	1	2	na	2003; generic
[D]	Recovery	Recovery	Energy recovery and recycling potential from steel and lead as described above.	See above						See above
*Data quality: **R** Reliability; **C** Completeness; **T** Temporal correlation; **G** Geographical correlation; **F** Further technological correlation; **S** Sample size; 1 is highest, 5 is lowest										

7.5 Allocations

Whenever a system boundary is crossed environmental inputs and outputs have to be assigned to the different products. Where multi-inputs are considered or where multi-outputs are considered the same applies. Part A prescribes to report where and how allocation occurs in the modeling of the LCA. In this LCA the following rules have been applied:

The preferred way to avoid allocation when a system boundary is crossed is to expand the system boundaries, e.g. including the cut-off parts. In this LCA, system boundaries are crossed for the manufacturing processes and reuse or reclaiming components after use. Multi-input, multi-output and recycling allocations are described below.

The model used in this report ensures that the sum of the allocated inputs and outputs of a unit process shall be equal to the inputs and outputs of the unit process before allocation. This means that no double counting or omissions of inputs or outputs through allocation is occurring.

7.5.1. Co-product allocation

Allocation for the manufacturing processes is done on a process to process level, with different processes assigned to different parts. Allocation for upstream processes follows the US-ecoinvent and ecoinvent assumptions, most notably the co-product allocation is either based on value or, if not available, on mass.

7.5.2. Allocation of multi-input processes

The preferred way to deal with assigning impacts to multi-inputs is to reflect the physical properties of the incoming flows. If a relationship can be established that is more suitable than mass, it should be used.

Waste treatment is typically a multi-input process. Several waste streams come together and are processed. Where specific data are available the composition of the waste flows has been used to model the contribution to the impacts from the waste treatment, this includes substitution benefits for energy utilization for combustion processes where relevant. Where no specific data are at hand average values are used.

7.5.3. Allocation procedure for reuse, recycling and recovery

All processes needed to utilize recycled content in the materials after collecting and sorting are assigned to the product utilizing the recycled content were not included. However, the previous use is cut off.

Metal parts of the finished product after use are also recycled. Life cycle stage end-of-life includes transportation to sorting facilities and processing is included up to the point of material that is ready for recycling, such as shredded metal.

All processes and transportation needed to actually recycle the materials are assigned to the recovery stage. This includes a credit given for the manufacturing of the primary material that is prevented by doing so. The credit varies for the different materials and is typically the scrap material that is used to make new product consistent with any other scenario for waste processing and is based on current average technology or practice. An example would be recycled fiber for cardboard. This is referred to as “up to the point of functional equivalence where the secondary material or fuel substitutes primary production and subtracting the impacts resulting from the substituted production of the product or substituted generation of energy from primary sources”.

7.5.4. Description of the allocation processes in the project report

Where multiple products are produced allocation is needed. Usually allocation is done by mass, unless another relation is more relevant. Allocation of the manufacturing data in this LCA includes the weight of the finished product and the yield of the specific product.

7.6 Description of the unit processes in the project report

The unit processes for the models are presented in terms of the GWP impact on a per product basis using a 4% cut-off, which shows an appropriate level of detail past the top level processes. These processes for LT307(A) and LT569 are presented in figures 7.4a and 7.4b, respectively. These diagrams can also be found by referenceing Appendix G.

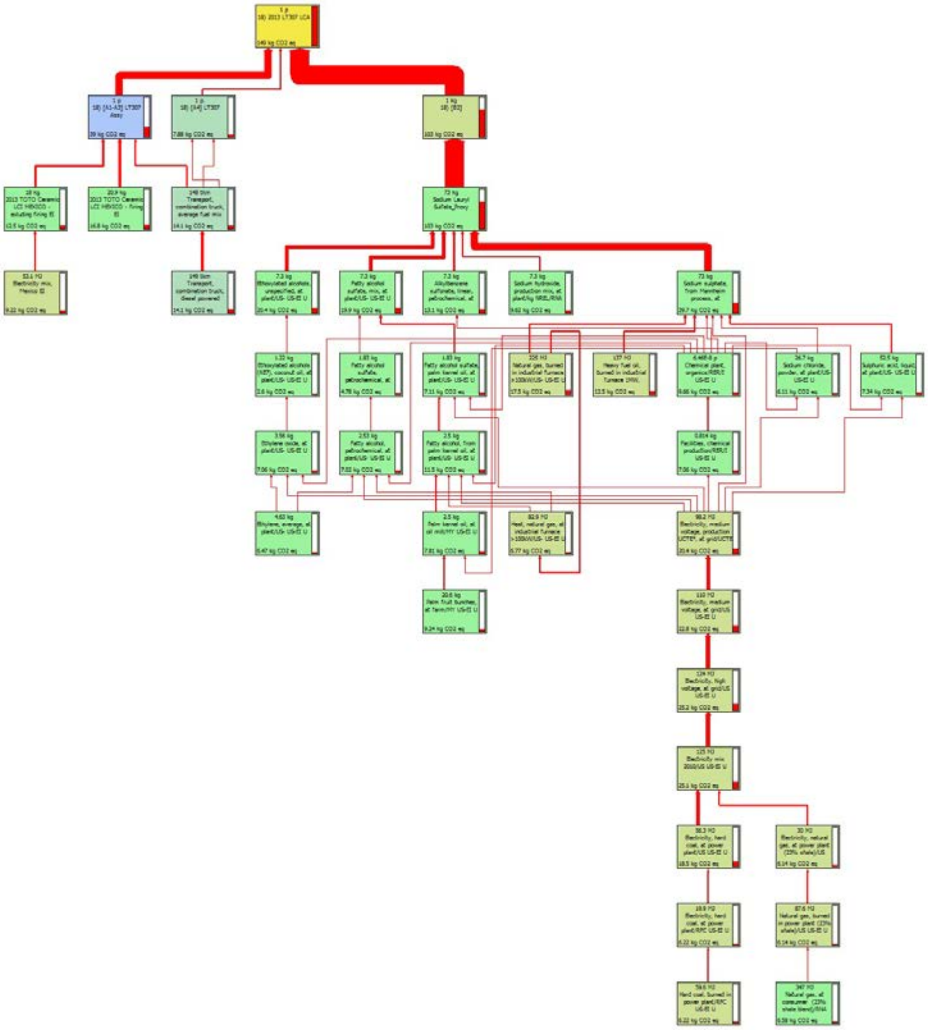

Figure 7.6a GWP contribution network with 4% cut-off for LT307(A)

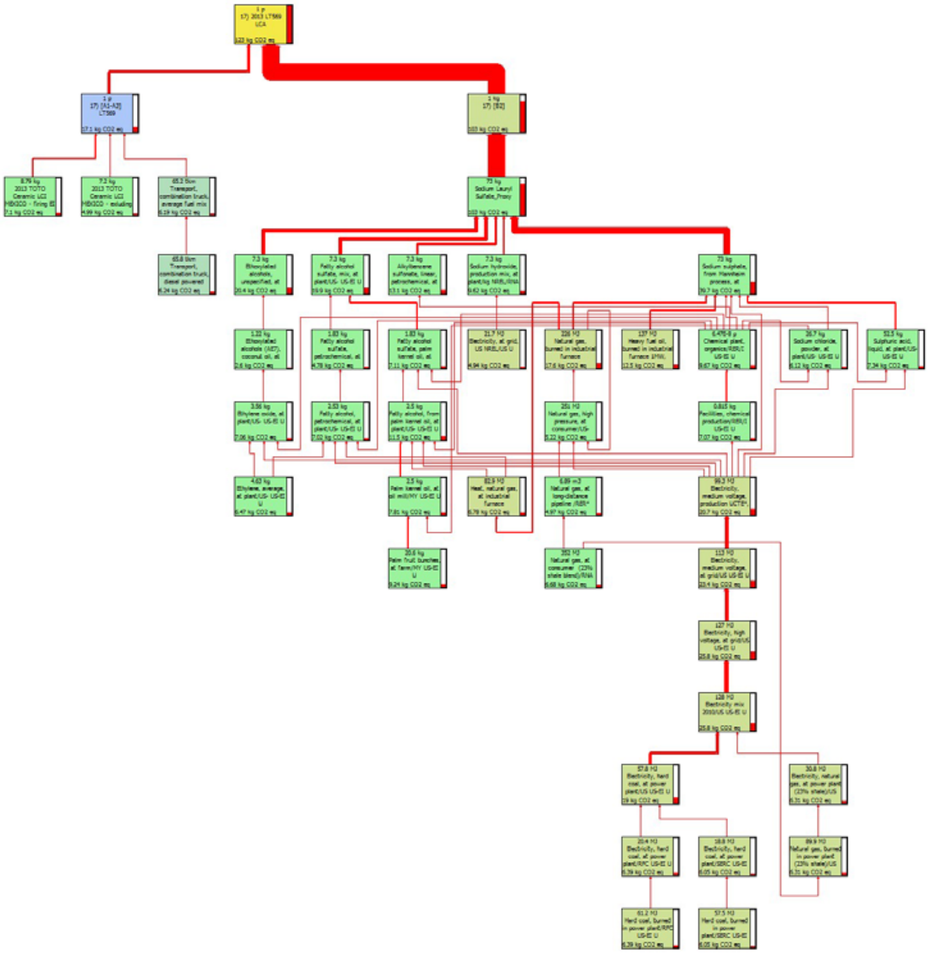

Figure 7.6b GWP contribution network with 4% cut-off for LT569

Additionally, the entire GWP contribution network (with a 0% cut-off) is shown with only top level processes displayed in figures 7.6c and 7.7c for LT307(A) and LT569, respectively.

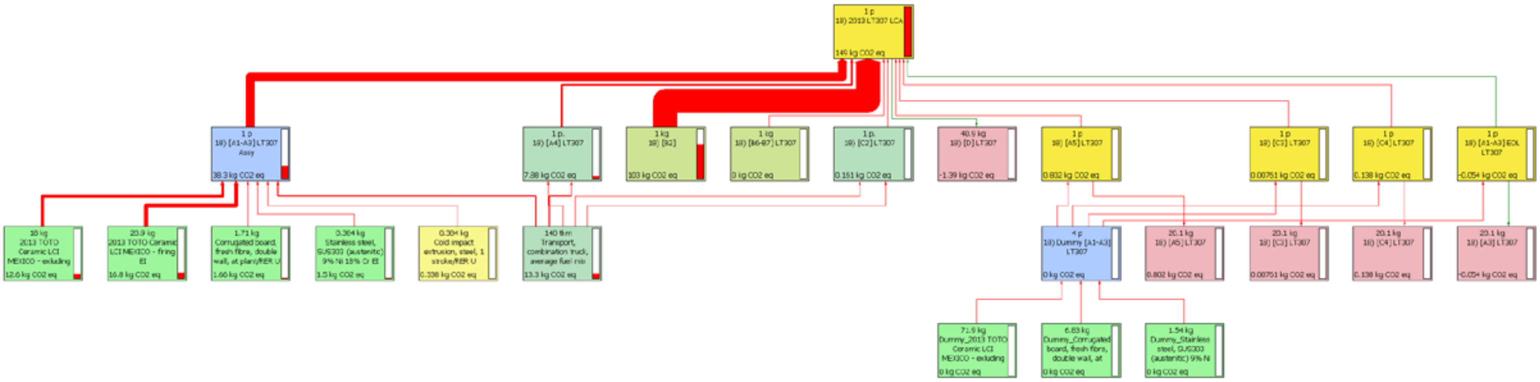

Figure 7.6c Whole top level process GWP contribution network for LT307(A)

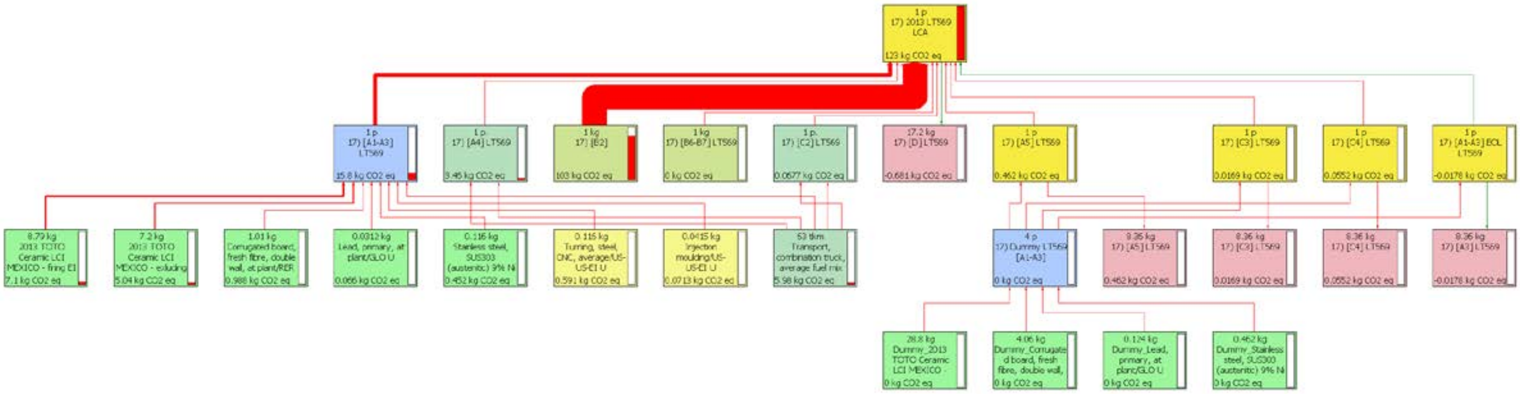

Figure 7.6d Whole top level process GWP contribution network for LT569

The data quality chart in section 7.4 presents details on unit processes and illustrates company data attribution to the life cycle model.

8 LIFE CYCLE INVENTORY ANALYSIS AND IMPACT ASSESSMENT

8.1 Indicators for the Life Cycle Inventory Analyisis as per EN 15804

Listed below are the indicators for the life cycle inventory analysis as per EN 15804. SimaPro 8 was used to perform the impact assessment using the CEN v2.07 methodology.

Table 8.1a Parameters to describe the use of resources

Parameter	Unit
Use of renewable primary energy excluding the renewable primary energy resources used as raw materials	MJ, calorific value ([Hi] lower calorific value)
Use of renewable primary energy resources used as raw materials	MJ, calorific value ([Hi] lower calorific value)
Total use of renewable primary energy resources (primary energy and primary energy resources used as raw materials)	MJ, calorific value ([Hi] lower calorific value)
Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials	MJ, calorific value ([Hi] lower calorific value)
Use of non-renewable primary energy resources used as raw materials	MJ, calorific value ([Hi] lower calorific value)
Total use of non-renewable primary energy resources (primary energy and primary energy resources used as raw materials)	MJ, calorific value ([Hi] lower calorific value)
Use of secondary materials	kg
Use of renewable secondary fuels	MJ, calorific value ([Hi] lower calorific value)
Use of non-renewable secondary fuels	MJ, calorific value ([Hi] lower calorific value)
Net use of fresh water resources	m^3

Table 8.1b Parameters describing waste categories

Parameter	Unit
Hazardous waste disposed	kg
Non-hazardous waste disposed	kg
Radioactive waste disposed	kg

Table 8.1c Parameters describing the output material flow

Parameter	Unit
Components for re-use	kg
Materials for recycling	kg
Materials for energy recovery	kg
Exported energy	MJ, heating value ([Hi] lower heating value) per energy carrier

8.1.1. Commercial Wall-Mount Lavatory LT307(A)

LCA results

The resource use, output flows and waste categories for LT307(A) are presented below (Table 8.1d-f4). Results are presented for the functional unit of 1 ton of the product. For results per 1 product unit, see Appendix H.

Table 8.1d Resource use per functional unit for LT307(A) by life cycle stage

Use of Resources													
		LT307(A)											
Parameter	**Unit**	**A1-A3**	**A4**	**A5**	**B1**	**B2**	**B3-B7**	**C1**	**C2**	**C3**	**C4**	**D**	**Total**
Use of renewable primary energy excluding the renewable primary energy	**MJ, calorific value** ([Hi] lower calorific value)	7.92E+02	6.38E+00	2.16E-01	0	1.14E+03	0	0	1.30E-01	3.75E-01	5.45E-01	-6.97E+01	1.87E+03
Use of renewable primary energy resources used as raw materials	**MJ, calorific value** ([Hi] lower calorific value)	3.06E+03	6.51E-01	8.58E-02	0	1.58E+01	0	0	1.33E-02	1.62E-01	2.62E-01	-2.63E+03	4.52E+02
Total use of renewable primary energy resources (primary energy and primary energy	**MJ, calorific value** ([Hi] lower calorific value)	3.85E+03	7.03E+00	3.02E-01	0	1.15E+03	0	0	1.43E-01	5.37E-01	8.07E-01	-2.70E+03	2.32E+03
Use of non-renewable primary energy excluding non-renewable primary energy	**MJ, calorific value** ([Hi] lower calorific value)	3.64E+04	5.36E+03	1.64E+01	0	1.02E+05	0	0	1.09E+02	1.82E+01	1.85E+02	-1.08E+03	1.43E+05
Use of non-renewable primary energy resources used as raw materials	**MJ, calorific value** ([Hi] lower calorific value)	0	0	0	0	0	0	0	0	0	0	0	0
Total use of non-renewable primary energy resources (primary energy and primary	**MJ, calorific value** ([Hi] lower calorific value)	3.64E+04	5.36E+03	1.64E+01	0	1.02E+05	0	0	1.09E+02	1.82E+01	1.85E+02	-1.08E+03	1.43E+05
Use of secondary material	**kg**	0	0	0	0	0	0	0	0	0	0	0	0
Use of renewable secondary fuels	**MJ, calorific value** ([Hi] lower calorific value)	0	0	0	0	0	0	0	0	0	0	0	0
Use of nonrenewable secondary fuels	**MJ, calorific value** ([Hi] lower calorific value)	0	0	0	0	0	0	0	0	0	0	0	0
Use of net fresh water*	**m3**	5.57E+03	3.53E+01	1.59E+00	0	9.44E+03	0	0	7.22E-01	2.03E-01	4.07E+00	-7.61E+02	1.43E+04

*Net fresh water consumption was calculated using the formula presented in Part A.

Table 8.1e Output flows per functional unit for LT307(A) by life cycle stage

Output Material Flows													
		LT307(A)											
Parameter	**Unit**	**A1-A3**	**A4**	**A5**	**B1**	**B2**	**B3-B7**	**C1**	**C2**	**C3**	**C4**	**D**	**Total**
Hazardous waste disposed	**kg**	1.30E+03	8.21E-03	4.03E-02	0	9.46E+02	0	0	2.46E-04	2.84E-01	1.36E-01	-1.30E+01	2.23E+03
Non-hazardous waste disposed	**kg**	3.08E+02	1.68E+00	8.74E-01	0	3.27E+03	0	0	3.43E-02	9.26E-01	2.07E+00	-8.37E+01	3.50E+03
Radioactive waste disposed	**kg**	3.37E+00	4.23E-03	3.38E-03	0	1.12E+01	0	0	8.63E-05	1.20E-02	6.81E-03	-2.58E-01	1.44E+01

Table 8.1f Waste categories per functional unit for LT307(A) by life cycle stage

Waste Categories													
		LT307(A)											
Parameter	**Unit**	**A1-A3**	**A4**	**A5**	**B1**	**B2**	**B3-B7**	**C1**	**C2**	**C3**	**C4**	**D**	**Total**
Components for re-use	**kg**	0	0	0	0	0	0	0	0	0	0	0	0
Materials for recycling	**kg**	6.94E-01	0	0	0	0	0	0	0	0	0	6.33E+01	6.40E+01
Materials for energy recovery	**kg**	0	0	0	0	0	0	0	0	0	0	0	0
Exported energy	**MJ, heating value** ([Hi] lower heating value) **per energy carrier**	0	0	0	0	0	0	0	0	0	0	0	0

8.1.2. Undercounter Lavatory LT569

LCA results

The resource use, output flows and waste categories for LT569 are presented below (Table 8.1g-i). Results are presented for the functional unit of 1 ton of the product. For results per 1 product unit, see Appendix H.

Table 8.1g Resource use per functional unit for LT569 by life cycle stage

Use of Resources													
		LT569											
Parameter	**Unit**	**A1-A3**	**A4**	**A5**	**B1**	**B2**	**B3-B7**	**C1**	**C2**	**C3**	**C4**	**D**	**Total**
Use of renewable primary energy excluding the renewable primary energy	**MJ, calorific value** ([Hi] lower calorific value)	7.45E+02	6.39E+00	2.93E-01	0	2.59E+03	0	0	1.25E-01	4.95E-01	4.96E-01	-5.60E+01	3.29E+03
Use of renewable primary energy resources used as raw materials	**MJ, calorific value** ([Hi] lower calorific value)	4.00E+03	6.52E-01	1.16E-01	0	3.59E+01	0	0	1.28E-02	2.14E-01	2.38E-01	-3.56E+03	4.75E+02
Total use of renewable primary energy resources (primary energy and primary energy	**MJ, calorific value** ([Hi] lower calorific value)	4.74E+03	7.04E+00	4.09E-01	0	2.63E+03	0	0	1.38E-01	7.09E-01	7.35E-01	-3.62E+03	3.76E+03
Use of non-renewable primary energy excluding non-renewable primary energy	**MJ, calorific value** ([Hi] lower calorific value)	3.59E+04	5.37E+03	2.22E+01	0	2.32E+05	0	0	1.05E+02	2.08E+01	1.68E+02	-1.22E+03	2.73E+05
Use of non-renewable primary energy resources used as raw materials	**MJ, calorific value** ([Hi] lower calorific value)	0	0	0	0	0	0	0	0	0	0	0	0
Total use of non-renewable primary energy resources (primary energy and primary	**MJ, calorific value** ([Hi] lower calorific value)	3.59E+04	5.37E+03	2.22E+01	0	2.32E+05	0	0	1.05E+02	2.08E+01	1.68E+02	-1.22E+03	2.73E+05
Use of secondary material	**kg**	0	0	0	0	0	0	0	0	0	0	0	0
Use of renewable secondary fuels	**MJ, calorific value** ([Hi] lower calorific value)	0	0	0	0	0	0	0	0	0	0	0	0
Use of nonrenewable secondary fuels	**MJ, calorific value** ([Hi] lower calorific value)	0	0	0	0	0	0	0	0	0	0	0	0
Use of net fresh water*	**m3**	5.00E+03	3.54E+01	2.16E+00	0	2.15E+04	0	0	6.93E-01	1.64E-01	3.70E+00	-5.89E+02	2.60E+04

*Net fresh water consumption was calculated using the formula presented in Part A.

Table 8.1h Output flows per functional unit for LT569 by life cycle stage

Output Material Flows													
		LT569											
Parameter	**Unit**	**A1-A3**	**A4**	**A5**	**B1**	**B2**	**B3-B7**	**C1**	**C2**	**C3**	**C4**	**D**	**Total**
Hazardous waste disposed	**kg**	5.88E+02	1.21E-02	5.46E-02	0	2.16E+03	0	0	2.36E-04	1.00E-01	1.24E-01	-1.07E+01	2.73E+03
Non-hazardous waste disposed	**kg**	1.76E+02	1.68E+00	1.18E+00	0	7.45E+03	0	0	3.29E-02	1.19E+00	1.88E+00	-9.01E+01	7.55E+03
Radioactive waste disposed	**kg**	1.97E+03	4.23E-03	4.58E-03	0	2.56E+01	0	0	8.28E-05	1.61E-02	6.20E-03	-2.98E-01	2.00E+03

Table 8.1i Waste categories per functional unit for LT569 by life cycle stage

Waste Categories													
		LT569											
Parameter	**Unit**	**A1-A3**	**A4**	**A5**	**B1**	**B2**	**B3-B7**	**C1**	**C2**	**C3**	**C4**	**D**	**Total**
Components for re-use	**kg**	0	0	0	0	0	0	0	0	0	0	0	0
Materials for recycling	**kg**	7.46E-01	0	0	0	0	0	0	0	0	0	8.41E+01	8.49E+01
Materials for energy recovery	**kg**	0	0	0	0	0	0	0	0	0	0	0	0
Exported energy	**MJ, heating value** ([Hi] lower heating value) **per energy carrier**	0	0	0	0	0	0	0	0	0	0	0	0

8.2 Indicators for Impact Assessment

Listed below are the required and optional indicators for impact assessment. A definition of these impact categories is included in appendix C. During the impact assessment stage of the modeling, the list of impacts, LCI, for substances that may have not been recognized by the impact assessment method was reviewed. SimaPro 8 was used to perform the impact assessment. Impacts were calculated using the TRACI 2.1 methodology.

Table 8.2a Required impact categories and units (TRACI 2.1)

Impact category	Unit
Global warming	CO_2 eq (carbon dioxide)
Ozone depletion	CFC-11 eq
Acidification	SO_2 eq (sulphur dioxide)
Eutrophication	N eq (nitrogen)
Smog	O_3 eq (ozone)

Table 8.2b Optional impact categories and units

Impact category	Unit
Carcinogenics	CTU_h
Ecotoxicity	CTU_e
Fossil fuel depletion	MJ surplus
Non carcinogenics	CTU_h
Respiratory effects	$PM_{2.5}$ eq (fine particulates)

The results from the impact assessment indicate potential environmental effects and do not predict actual impacts on category endpoints, the exceedance of thresholds or safety margins or risks.

8.2.1. Commercial Wall-Mount Lavatory LT307(A)

Impacts for LT307(A) are presented below. Results are presented per 1 ton of the product. For results per 1 product unit, categorized by life cycle phase, see Appendix H.

Table 8.2.1 Required life cycle impacts per functional unit for LT307(A) – absolute results (TRACI 2.1)

Environmental Impacts													
		LT307(A)											
Impact category	**Unit**	**[A1-A3]**	**[A4]**	**[A5]**	**[B1]**	**[B2]**	**[B3-B7]**	**[C1]**	**[C2]**	**[C3]**	**[C4]**	**[D]**	**Total**
Global warming	**CO_2 eq** (carbon dioxide)	2.08E+03	4.21E+02	3.92E+01	0	5.50E+03	0	0	8.60E+00	1.76E+00	7.40E+00	-7.58E+01	7.98E+03
Ozone depletion	**CFC-11 eq**	2.78E-04	9.60E-08	1.46E-07	0	3.63E-04	0	0	1.96E-09	2.24E-07	2.75E-06	-6.17E-06	6.38E-04
Acidification	**SO_2 eq**	6.53E+00	2.57E+00	1.10E-02	0	7.61E+01	0	0	5.05E-02	1.55E-02	5.61E-02	-7.12E-01	8.47E+01
Eutrophication	**N eq (nitrogen)**	7.74E-01	1.51E-01	6.07E-02	0	6.11E+00	0	0	2.97E-03	2.96E-03	5.49E-03	-1.40E-01	6.97E+00
Smog	**O_3 eq** (ozone)	1.18E+02	7.06E+01	1.13E-01	0	3.28E+02	0	0	1.38E+00	4.01E-01	1.50E+00	-8.55E+00	5.11E+02

Table 8.2.2 Optional life cycle impacts per functional unit for LT307(A) – absolute results

Human Health Impacts													
		LT307(A)											
Impact category	**Unit**	**[A1-A3]**	**[A4]**	**[A5]**	**[B1]**	**[B2]**	**[B3-B7]**	**[C1]**	**[C2]**	**[C3]**	**[C4]**	**[D]**	**Total**
Carcinogenics	**CTUh**	7.23E-05	5.68E-06	1.91E-08	0	9.51E-05	0	0	1.16E-07	1.19E-07	7.57E-08	-1.75E-05	1.56E-04
Non-carcinogenics	**CTUh**	2.01E-04	5.45E-05	1.97E-07	0	6.41E-04	0	0	1.11E-06	9.88E-07	4.15E-07	-3.07E-05	8.68E-04
Respiratory effects	**PM2.5 eq**	6.87E-01	4.58E-02	8.52E-04	0	6.40E+00	0	0	8.99E-04	3.34E-03	5.72E-03	-1.28E-01	7.01E+00
Ecotoxicity	**CTUe**	1.96E+03	1.05E+03	1.09E+00	0	5.51E+03	0	0	2.15E+01	2.77E+00	3.09E+00	-2.23E+02	8.33E+03
Resource Depletion													
		LT307(A)											
Impact category	**Unit**	**[A1-A3]**	**[A4]**	**[A5]**	**[B1]**	**[B2]**	**[B3-B7]**	**[C1]**	**[C2]**	**[C3]**	**[C4]**	**[D]**	**Total**
Fossil fuel depletion	**MJ surplus**	4.27E+03	7.46E+02	1.50E+00	0	1.09E+04	0	0	1.52E+01	2.11E+00	2.48E+01	-8.41E+01	1.59E+04

Variations

There is no variation relevant to the impacts, as the model for LT307(A) is for one specific product, manufactured in one location.

8.2.2. Undercounter Lavatory LT569

Impacts for LT569 are presented below. Results are presented per 1 ton of the product. For results per 1 product unit, categorized by life cycle phase, see Appendix H.

Table 8.2.3 Required life cycle impacts per functional unit for LT569 – absolute results (TRACI 2.1)

Environmental Impacts													
		LT569											
Impact category	**Unit**	**[A1-A3]**	**[A4]**	**[A5]**	**[B1]**	**[B2]**	**[B3-B7]**	**[C1]**	**[C2]**	**[C3]**	**[C4]**	**[D]**	**Total**
Global warming	**CO_2 eq** (carbon dioxide)	2.09E+03	4.22E+02	5.32E+01	0	1.25E+04	0	0	8.26E+00	2.12E+00	6.74E+00	-8.53E+01	1.50E+04
Ozone depletion	**CFC-11 eq**	2.68E-04	9.62E-08	1.97E-07	0	8.28E-04	0	0	1.88E-09	2.61E-07	2.50E-06	-7.72E-06	1.09E-03
Acidification	**SO_2 eq**	7.01E+00	2.57E+00	1.49E-02	0	1.74E+02	0	0	4.85E-02	1.84E-02	5.11E-02	-8.30E-01	1.83E+02
Eutrophication	**N eq** (nitrogen)	9.27E-01	1.51E-01	8.22E-02	0	1.39E+01	0	0	2.85E-03	3.76E-03	5.00E-03	-1.81E-01	1.49E+01
Smog	**O_3 eq** (ozone)	1.20E+02	7.07E+01	1.53E-01	0	7.47E+02	0	0	1.32E+00	4.70E-01	1.37E+00	-1.05E+01	9.31E+02

Table 8.2.4 Optional life cycle impacts per functional unit for LT569 – absolute results

Human Health Impacts													
		LT569											
Impact category	**Unit**	**[A1-A3]**	**[A4]**	**[A5]**	**[B1]**	**[B2]**	**[B3-B7]**	**[C1]**	**[C2]**	**[C3]**	**[C4]**	**[D]**	**Total**
Carcinogenics	**CTUh**	6.44E-05	5.68E-06	2.59E-08	0	2.17E-04	0	0	1.11E-07	1.59E-07	6.89E-08	-1.29E-05	2.74E-04
Non-carcinogenics	**CTUh**	2.64E-04	5.46E-05	2.67E-07	0	1.46E-03	0	0	1.07E-06	1.33E-06	3.78E-07	-2.46E-05	1.76E-03
Respiratory effects	**PM2.5 eq**	6.95E-01	4.59E-02	1.16E-03	0	1.46E+01	0	0	8.63E-04	4.20E-03	5.21E-03	-1.26E-01	1.52E+01
Ecotoxicity	**CTUe**	2.02E+03	1.06E+03	1.48E+00	0	1.26E+04	0	0	2.06E+01	3.69E+00	2.81E+00	-1.74E+02	1.55E+04
Resource Depletion													
		LT569											
Impact category	**Unit**	**[A1-A3]**	**[A4]**	**[A5]**	**[B1]**	**[B2]**	**[B3-B7]**	**[C1]**	**[C2]**	**[C3]**	**[C4]**	**[D]**	**Total**
Fossil fuel depletion	**MJ surplus**	4.15E+03	7.47E+02	2.04E+00	0	2.49E+04	0	0	1.46E+01	2.36E+00	2.25E+01	-9.94E+01	2.98E+04

Variations
There is no variation relevant to the impacts, as the model for LT569 is for one specific product, manufactured in one location.

8.3 Indicators for the Impact Assessment as per EN 15804

As conformance with EN 15804 was not required, the CML characterization factors were not calculated for this assessment.

9 LIFE CYCLE INTERPRETATION

9.1 Commercial Wall-Mount Lavatory LT307(A)

Cradle-to-gate
Figure 9.1a shows the results for the finished product. Ceramic production is impactful to most of the categories. The ceramic dominates all impact categories except for ecotoxicity, carcinogenics, and non-carcenogenics. These categories are more impacted by stainless steel and/or truck transport. Manufacture of ceramic and metals for installation parts utilize a significant amount of resources such as electricity, natural gas, and water. Stainless steel and truck transport also have relevant impact to all other categories, except ozone depletion. Corrugated board has a significant contribution to

the eutrophication category. Paper used for this product has very little impact to each category.

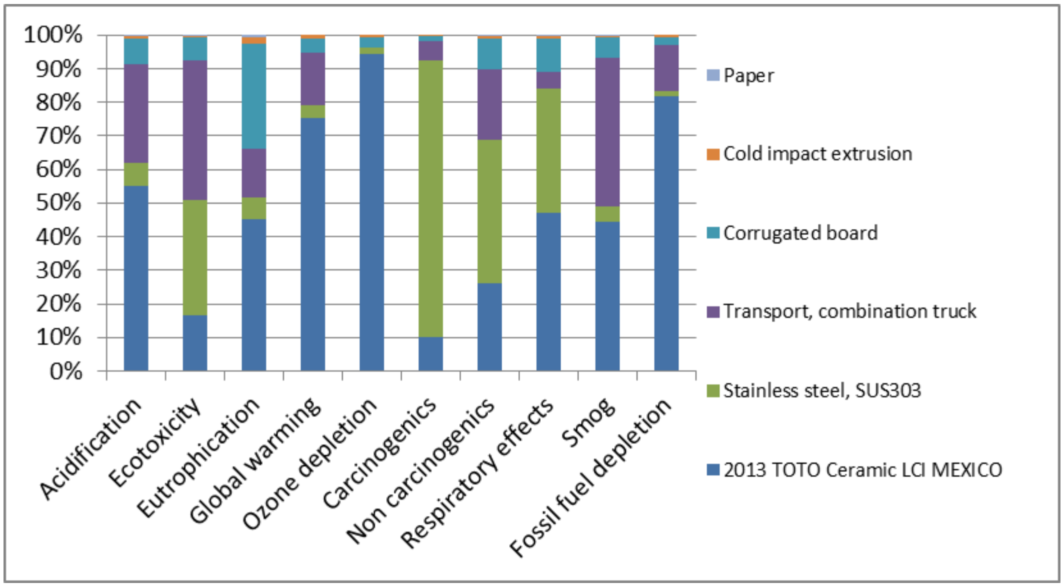

Figure 9.1a Cradle-to-gate impacts for LT307(A) – relative results

Variations

There is no variation relevant to the impacts, as the model for LT307(A) is for one specific product, manufactured in one location.

Full life cycle

Figure 9.1b shows the TRACI 2.1 results for the full life cycle of the product. The use stage [B2] and the product stage [A1-A3] are dominating the results for all impact categories. For the use phase, the significant contribution is due to the cleaning agents required for maintenance. The product itself [A1-A3] has a significant contribution to ozone depletion and carcinogenics, and a relatively significant contribution to global warming and fossil fuel depletion. The impacts for the product itself [A1-A3] are discussed above in the cradle-to-gate section. The contribution of the delivery and installation of the product [A4-A5] which are covered under the construction stage is associated with the transportation by truck for delivery to the market ([A4]). This stage has a contribution of up to 14% to the impact categories and is mostly critical to ecotoxicity and smog. The end-of-life scenario [D] includes recycling and benefits from this by preventing the need to produce primary materials. Recovery is somewhat relevant to a few categories, such as carcinogens and non carcinogenics. Overall the recovery stage contributes 1 to 11% to the impact categories. The end-of-life stage that includes the processes for dismantling and final waste treatment [C1-C4] of the product does not have a significant impact.

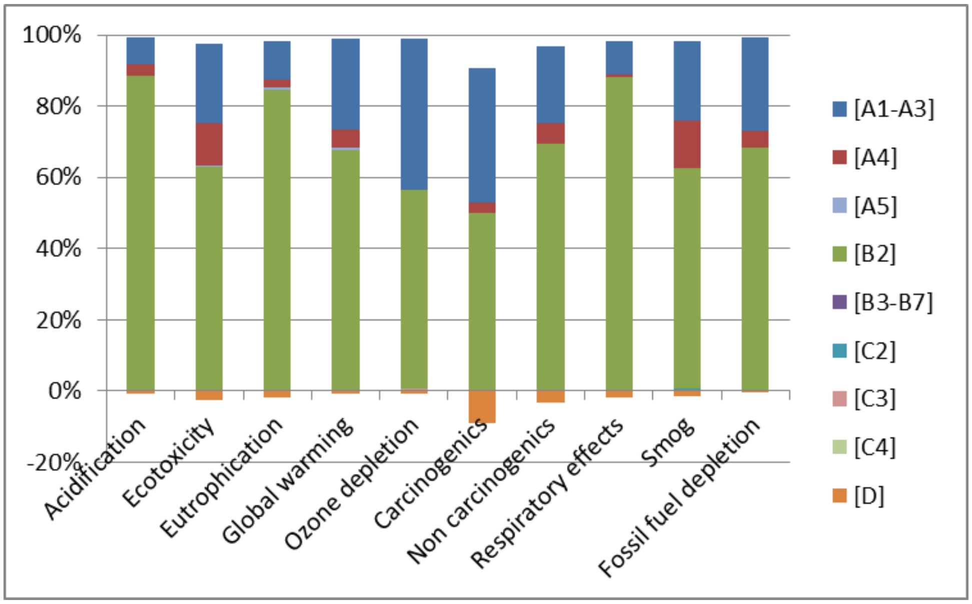

Figure 9.1b Life cycle impacts for LT307(A) – relative results

Figure 9.1c shows the results for resource use, waste, and output flows for the full life cycle of the product. Only parameters with relevant impacts are shown. The use stage [B2] and the product stage [A1-A3] are dominating the results for all impact categories. For the use phase, the significant contribution is due to the cleaning agents required for maintenance. The use phase contributes most to the non-hazardous waste parameter, but is relevant to every other parameter with the exception of use of renewable primary energy resources used as raw materials, total use of renewable primary energy resources, and materials for recycling. The product stage is heavily impactful to all parameters except materials for recycling and non-hazardous waste disposal. The impacts for the product itself [A1-A3] are discussed above in the cradle-to-gate section.

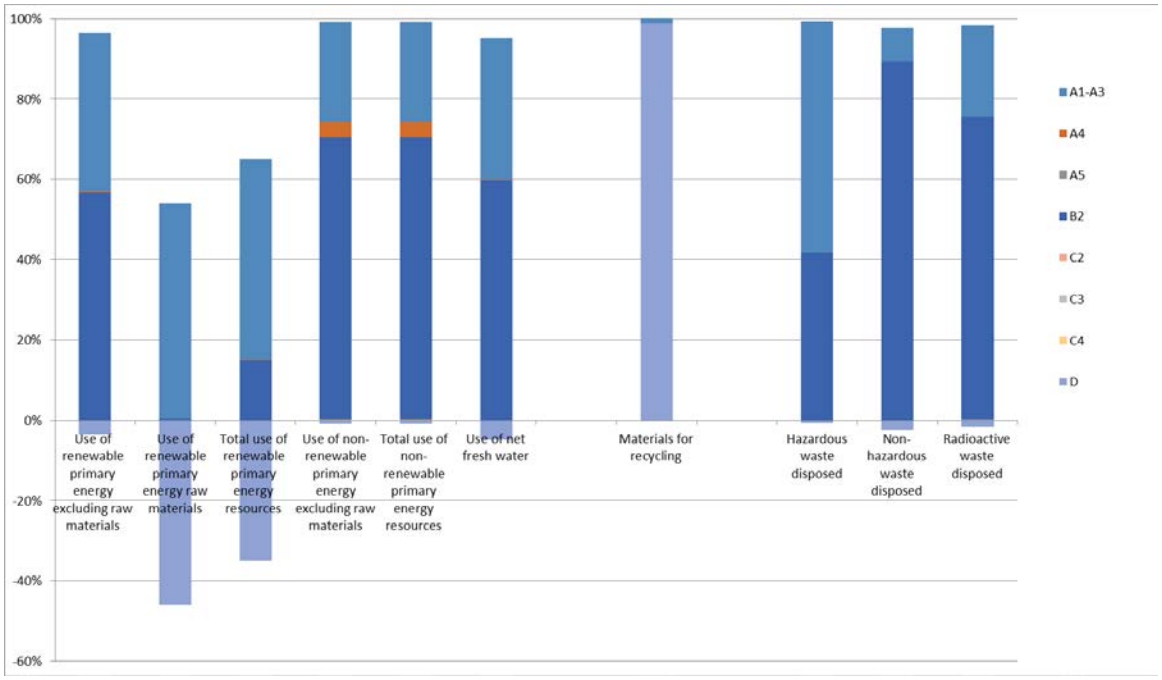

Table 9.1c Resource use, material flows, and waste for LT569 – Relative results

9.2 Undercounter Lavatory LT569

Cradle-to-gate

Figure 9.2a shows the results for the finished product. Ceramic production is impactful to most of the categories. Manufacture of ceramics utilizes a significant amount of resources such as electricity, natural gas, and water. The ceramic parts dominate all impact categories, with the exception of ecotoxicity, eutrophication, carcinogenics, and non-carcinogenics. Truck transport is relevant to all categories except ozone depletion. Stainless steel is a significant contributor to ecotoxicity, carcinogenics, non-carcinogenics, and respiratory effects. Lead is most relevant in the non-carcinogenic category. Corrugated board is also relevant to most impact categories, especially eutrophication. Turning steel is somewhat relevant to many of the impact categories, especially carcinogenics, non-carcinogenics, and respiratory effects. Paper used for this product has very little impact to each category.

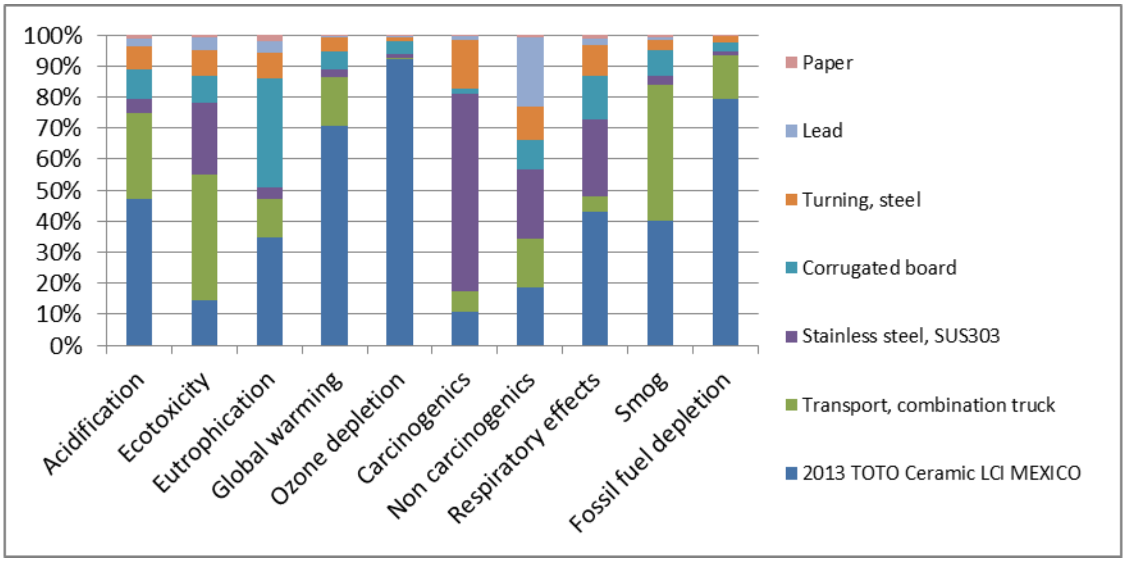

Figure 9.2a Cradle-to-gate impacts for LT569 – relative results

Variations

There is no variation relevant to the impacts, as the model for LT569 is for one specific product, manufactured in one location.

Full life cycle

Figure 9.2b shows the TRACI 2.1 results for the full life cycle of the product. The use stage [B2], followed by the product stage [A1-A3] dominates the results for all impact categories. For the use phase, the significant contribution is mostly due to the cleaning agents required for maintenance. The product itself [A1-A3] has a significant contribution to ozone depletion and carcinogenics. The impacts for the product itself [A1-A3] are discussed above in the cradle-to-gate section. The contribution of the delivery and installation of the product [A4-A5] which are covered under the construction stage is associated with the transportation by truck for delivery to the market ([A4]). This stage has a contribution of 0 to 8% to the impact categories. The end-of-life scenario [D] includes recycling and benefits from this by preventing the need to produce primary materials. Recovery is somewhat relevant to the carcinogens category. Overall the recovery stage contributes 1 to 5% to the impact categories. The end-of-life stage that includes the processes for dismantling and final waste treatment [C1-C4] of the product does not have a significant impact.

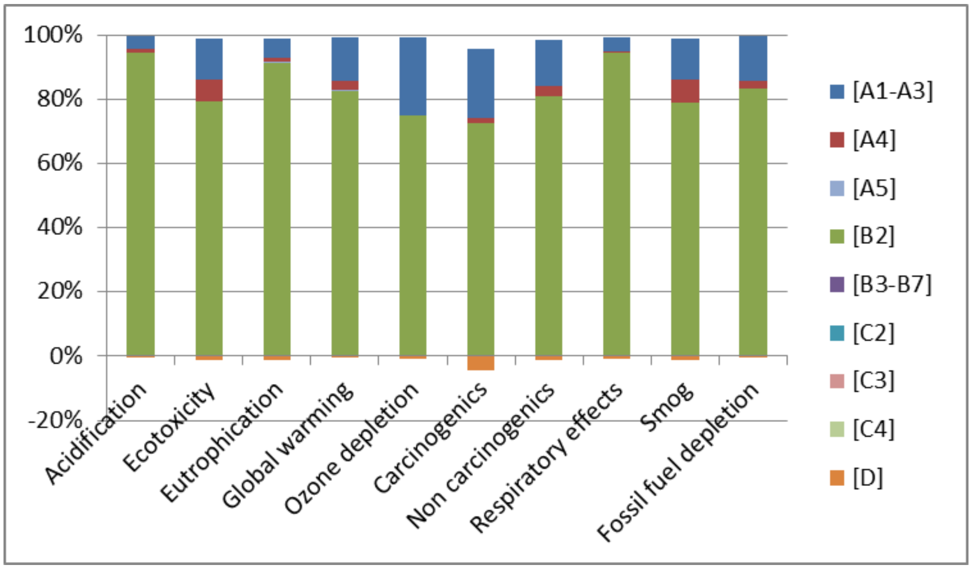

Figure 9.2b Life cycle impacts for LT569 – relative results

Figure 9.2c shows the results for resource use, waste, and output flows for the full life cycle of the product. Only parameters with relevant impacts are shown. The use stage [B2] and the product stage [A1-A3] are dominating the results for all impact categories. For the use phase, the significant contribution is due to the cleaning agents required for maintenance. The use phase contributes most to the non-hazardous waste parameter, but is relevant to every other parameter with the exception of use of renewable primary energy resources used as raw materials, total use of renewable primary energy resources, and materials for recycling. The product stage is heavily impactful to all parameters except materials for recycling and non-hazardous waste disposal. The impacts for the product itself [A1-A3] are discussed above in the cradle-to-gate section.

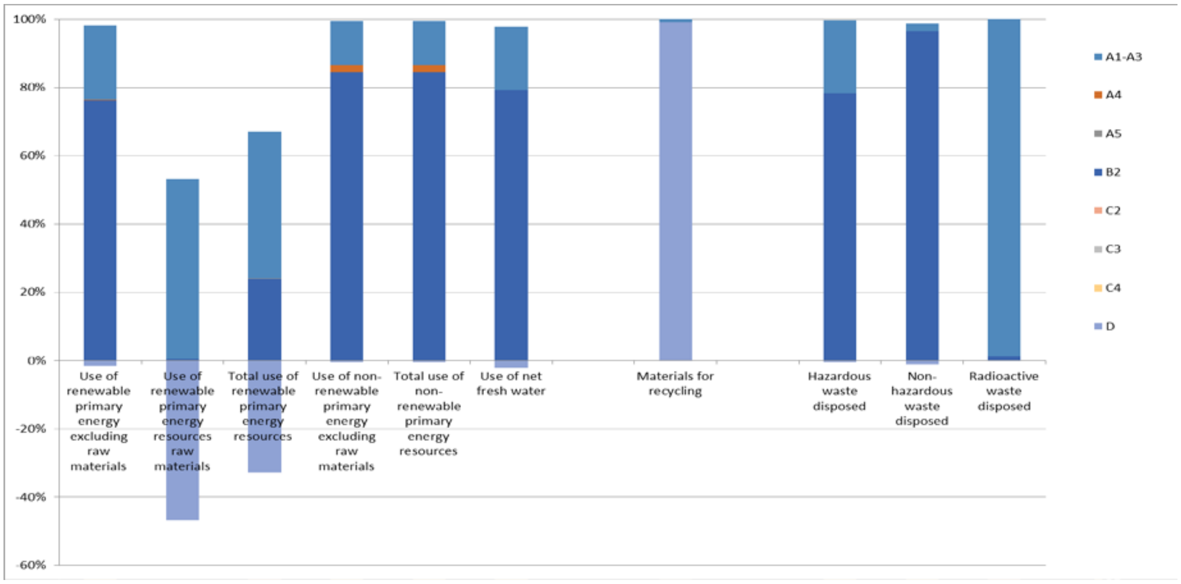

Figure 9.2c Resource use, material flows, and waste for LT569 – Relative results

Recommendations Based on Interpretation

During the process of compiling this report with the help of many TOTO employees, an insight into the environmental performance of a selection of TOTO products was gained. Additionally, the major contributions and differences were also learned.

Based on these insights we make the following recommendations to TOTO:

- Because one of the greatest impactors to the environment is the manufacturing, evaluate improvement options for the major contributions against required investments to drive down in the impact. Good candidates are as follows:
    - The recycled content of the material input
    - The energy efficiency of the firing kiln
    - Electricity use
    - An alternative destination for sludge waste so that it may be upcycled into other end products
    - Product yield. The yield of one of the products is roughly 80%.
    - On-site sourced water or 100% water recycling process. A review of technologies, validated with LCA, can help TOTO Mexico and TOTO USA have a better positioning in the market as being socially and environmentally responsible beyond using less water to actually eliminate its water sourcing.
- As a general approach, evaluate changes in the manufacturing process or supply chain using LCA technologies to choose the best alternative before making a purchasing or investment decision. This will inform the decision making process with upfront insight in how it will impact the LCA.
- The use phase is the most impactful phase to the environment. Because the use phase for lavatories is scenario based, it is important to gain a better understanding of the actual behaviors and practices involved during use. TOTO, along with other industry leaders, are encouraged to gain this understanding. Improvements to products relating to the use phase are more effective when this knowledge exists.
- To improve future studies, create a process for LCI data collection for the manufacturing process of the suppliers. This should streamline the data collection for different locations defining the primary sources for the data, and alignment of the reported data. There is a need for better processing data, like energy consumption and yield. One topic within this is the amount of recycled content which provides an opportunity for environmental performance improvement.

Limitations

The LCA is limited in the following ways:

- TMX responded to the request for data and cooperated with the LCA practitioner to the best of their ability; however, in some cases, data was missing. Manufacturing assumptions listed in section 6.5.9 originate from the quality of their response. It is therefore recommended that the supplier will be contacted and engaged for future LCA work again and focus on some more details for the most important processes.

- No data on recycled content for any component of the modeled products was provided. No assumption of secondary material was made even when information was provided informally. This is likely a worst-case scenario. These assumptions need to be revisited in future LCA projects. There is a significant improvement potential for using more recycled content.
- Scenarios have been used for the use phase and for the end-of-life treatment of the materials. The representativeness of scenario data can be improved through further study by the company or by the industry as a whole.
- Literature data has been used based on the USLCI database and the US-ecoinvent database. With future updates and more and more LCA information becoming available, more representative and less generic data should be used for future LCA projects where possible.

A summary of the most relevant assumptions is presented in section 6.5.9.

Discussion of the role of excluded elements:

This study followed the completeness criteria stated in Section 6.6 herein. Small amounts of input materials have not been included based on the mass criteria. Excluded flows are also listed in section 6.6.

Discussion of the precision, completeness and representativeness of data:

TOTO Mexico's response to the request for data was comprehensive; however, the collection process gave little insight to the LCA practitioner as to how data was gathered and calculated. The LCA practitioner used back calculations and mass balance calculations in order to assure data was plausible, consistent and complete. No data on the recycled content of the components of the modeled products was provided. The LCA practitioner made no assumption in that regard and assumed worst-case scenario in that all materials were primary. The impact of this assumption is expected to be insignificant because the material inputs are not major drivers of the LCA results for the modeled products. This study used literature data where supplier data was not made available based on the USLCI database and the US-ecoinvent database. With future updates and more and more LCA information becoming available, more representative and less generic data should be used for future LCA projects where possible. The impact of this limitation could be relevant as it relates to recycled content, yield and processing energy which are relevant drivers of the LCA results. It is recommended that suppliers shall be contacted and engaged for future LCA work especially as TOTO moves towards a more integrated People, Planet, Profit strategy.

The study used scenarios for the use phase and end of life. Since the use phase is important for the results of the LCA, it is recommended to discuss and validate the approach with industry stakeholders to establish a common practice.

Discussion related to the impact of value judgments:

Manufacturing of product in TMX is very similar to manufacture at TUS. Ceramics and production experts work with and visit TMX on a regular basis. Where assumptions relating to TMX manufacturing were made, experts from TUS were consulted. These assumptions, such as water content of sludge, are likely to have an insignificant impact the results. Worst-case scenarios were adapted in the study and that was encouraged by TOTO USA. A list of assumptions is listed in section 6.5.9.

Sensitivity analysis

A sensitivity analysis was performed using the highest and lowest values for the most important choices and assumptions to check the robustness of the results of the LCA (disregarding outliers is appropriate). Identifying which choices or assumption influence the results in any environmental parameter by more than 20% shall be reported. The previous section includes the variations within the product groups which are dominated by the use phase and the product composition as indicated.

Additionally, the chosen approach for the following parameters must also be reported:

The variation due to using a group-average using the highest and lowest values in the sensitivity analysis. Outliers can be disregarded.	This does not apply as only TOTO products are included.
Allocation of recycling processes	A sensitivity analyses is included below in this section.
Allocation of multi-input and multi-output processes	Allocations follow a mass based approach in the collected data which is the most appropriate for the unit processes modeled. Allocation approaches in the background data follow the ecoinvent methodology.

Ceramics and allocation for recycling and recycled content
Recycled content is a relevant factor in many LCA studies. Recycled content is modeled using materials that are processed to make new materials in this study. After use recycling is credited to the offset of virgin metals up to the point of intermediates before they are finished into products. This is a substitution based approach and it complies with Part A.

Another approach could be to model a full cut off and not to include the substitution at the end of use and only model the recycling benefits at the manufacturing stage by means of using recycling content and hence less virgin content. The impact of this allocation choice can be seen by looking at the graphs in the previous section. In essence this would eliminate the benefits that show up in the recovery stage. The impact is minimal for all products and in most impact categories.

10 DOCUMENTATION OF ADDITIONAL INFORMATION

10.1 Laboratory results and scenario-related information

No laboratory testing was conducted, and therefore, no results are available.

10.2 Documentation for calculating the Reference Service Life (RSL)

The reference service life of commercial lavatories is 20 years as defined by Part B [7]. 20 years is an industry accepted average lifespan that is based on the economic lifespan of the product.

11 REFERENCES

[1] ISO 14044, “Environmental management - Life cycle assessment - Requirements and guidelines”, ISO14044:2006

[2] ISO 14025, “Environmental labels and declarations -- Type III environmental declarations -- Principles and procedures”, ISO14025:2006

[3] J. Bare (2011) TRACI 2.0: the tool for the reduction and assessment of chemical and other environmental impacts 2.0. Clean Technologies and Environmental Policy. 13(5); United States Environmental Protection Agency (2012). Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts (TRACI) User's Manual. Document ID: S-10637-OP-1-0.

[4] A. Lautier, et al. (2010). Development of normalization factors for Canada and the United States and comparison with European factors. Science of the Total Environment. 409: 33-42.

[5] Bare, Jane; Gloria, Tom and Norris, Greg, Development of the Method and U.S. Normalization Database for Life Cycle Impact Assessment and Sustainability Metrics, Environmental Science and Technology, / VOL. 40, NO. 16, 2006

[6] UL Environment and Institut Bauen und Umwelt e.V., Königswinter (pub.): Product Category Rules for Construction Products from the range of Environmental Product Declarations of Institut Bauen und Umwelt (IBU), Part A: Calculation Rules for the Life Cycle Assessment and Requirements on the Background Report. July 2014, version 1.3.

[7] UL Environment and Institut Bauen und Umwelt e.V. (IBU). Product Category Rules Part B: Requirements on the Environmental Product Declaration for Sanitary ceramics.

ACRONYMS

EPD	Environmental Product Declaration
ISO	International Standardization Organization
LCA	life cycle assessment
LCI	life cycle inventory
LCIA	life cycle impact analysis
LHV	Low Heating Value
PCR	Product Category Rule document
TMX	TOTO Mexico, manufacturing facility

GLOSSARY

For the purposes of this report, the terms and definitions given in ISO 14020, ISO 14025, ISO 14040, ISO 14041, ISO 14042, ISO 14043, ISO 14044 and ISO 21930 apply. The most important ones are included here:

aggregation	aggregation of data
allocation	partitioning the input or output flows of a process or a product system between the product system under study and one or more other product systems
ancillary input	material input that is used by the unit process producing the product, but does not constitute part of the product
capital good	Means, for instance ancillary input needed for activities, and all handling equipment during the life cycle that can be characterized by a relative long lifespan and can be (re)used many times
category endpoint	attribute or aspect of natural environment, human health, or resources, identifying an environmental issue giving cause for concern
characterization factor	factor derived from a characterization model which is applied to convert an assigned life cycle inventory analysis result to the common unit of the category indicator
comparative assertion	environmental claim regarding the superiority or equivalence of one product versus a competing product that performs the same function
completeness check	process of verifying whether information from the phases of a life cycle assessment is sufficient for reaching conclusions in accordance with the goal and scope definition
consistency check	process of verifying that the assumptions, methods and data are consistently applied throughout the study and are in accordance with the goal and scope definition performed before conclusions are reached
co-product	any of two or more products coming from the same unit process or product system
critical review	process intended to ensure consistency between a life cycle assessment and the principles and requirements of the International Standards on life cycle assessment
cut-off criteria	specification of the amount of material or energy flow or the level of environmental significance associated with unit processes or product system to be excluded from a study
data quality	characteristics of data that relate to their ability to satisfy stated requirements

elementary flow	material or energy entering the system being studied that has been drawn from the environment without previous human transformation, or material or energy leaving the system being studied that is released into the environment without subsequent human transformation
energy flow	input to or output from a unit process or product system, quantified in energy units
environmental aspect	element of an organization's activities, products or services that can interact with the environment
environmental measure	series of certain quantities, based on economic flows and weighing of environmental effects.
environmental mechanism	system of physical, chemical and biological processes for a given impact category, linking the life cycle inventory analysis results to category indicators and to category endpoints
environmental profile	a series of environmental effects
evaluation	element within the life cycle interpretation phase intended to establish confidence in the results of the life cycle assessment
feedstock energy	heat of combustion of a raw material input that is not used as an energy source to a product system, expressed in terms of higher heating value or lower heating value
functional lifespan	the period of time during which a building or a building element fulfils the performance requirements
functional unit	quantified performance of a product system for use as a reference unit
impact category	class representing environmental issues of concern to which life cycle inventory analysis results may be assigned
impact category indicator	quantifiable representation of an impact category
Input	product, material or energy flow that enters a unit process
interested party	individual or group concerned with or affected by the environmental performance of a product system, or by the results of the life cycle assessment
intermediate flow	product, material or energy flow occurring between unit processes of the product system being studied
intermediate product	output from a unit process that is input to other unit processes that require further transformation within the system
life cycle	consecutive and interlinked stages of a product system, from raw material acquisition or generation from natural resources to final disposal
life cycle assessment LCA	compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle
life cycle impact assessment LCIA	phase of life cycle assessment aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts for a product system throughout the life cycle of the product
life cycle interpretation	phase of life cycle assessment in which the findings of either the inventory analysis or the impact assessment, or both, are evaluated in relation to the defined goal and scope in order to reach conclusions and recommendations
life cycle inventory analysis LCI	phase of life cycle assessment involving the compilation and quantification of inputs and outputs for a product throughout its life cycle
life cycle inventory analysis result LCI result	outcome of a life cycle inventory analysis that catalogues the flows crossing the system boundary and provides the starting point for life cycle impact assessment
multi-input process	a unit process where more than one flow enters from different product systems for combined processing
multi-output process	a unit process that results in more than one flow used in different product systems
output	product, material or energy flow that leaves a unit process
performance	behavior based on use

primary material	a material produced from raw materials
primary production	a production process that produces primary material
process	set of interrelated or interacting activities that transforms inputs into outputs
process energy	energy input required for operating the process or equipment within a unit process, excluding energy inputs for production and delivery of the energy itself
product	any goods or service
product flow	products entering from or leaving to another product system
product system	collection of unit processes with elementary and product flows, performing one or more defined functions, and which models the life cycle of a product
raw material	primary or secondary material that is used to produce a product
recycling	all processes needed to recycle a material, product or element as a material input
reference flow	measure of the outputs from processes in a given product system required to fulfill the function expressed by the functional unit
releases	emissions to air and discharges to water and soil
return system	a system to collect waste material from the market for the purpose of recycling or reuse
reuse	all processes needed to reuse a material, product or element in the same function
secondary material	material input produced from recycled materials
secondary production	production process that produces secondary material
sensitivity analysis	systematic procedures for estimating the effects of the choices made regarding methods and data on the outcome of a study
system boundary	set of criteria specifying which unit processes are part of a product system
third party	person or body that is independent of the involved parties, and as such recognized
transparency	open, comprehensive and understandable presentation of information
type -III-environmental declaration	quantified environmental data of a product with a predefined set of categories based on the ISO 14040 standards, without excluding the presentation of supplementing relevant environmental data, provided within the scope of a type-III-environmental declaration framework
type -III-environmental declaration framework	voluntary process of an industrial sector or independent body to develop a type- III-environmental declaration, including a framework that defines the essential requirements, the selection of categories or parameters, the level of involvement of third parties and a template for external communication
uncertainty analysis	systematic procedure to quantify the uncertainty introduced in the results of a life cycle inventory analysis due to the cumulative effects of model imprecision, input uncertainty and data variability
unit process	smallest element considered in the life cycle inventory analysis for which input and output data are quantified
waste	substances or objects which the holder intends or is required to dispose of

APPENDIX A. LCI AND OTHER STARTING POINTS FOR THE MANUFACTURING PROCESS

The LCI for manufacturing and parts are reported in a separate spreadsheet “Ceramics Lavatory BOM 7-2015”. It includes all parts, processes and other LCI collected to model the products. An overview of the material list for the products is included herein. Also included is an LCI data summary table for the manufacturing processes at the TOTO Mexico facility.

Table A.1 Raw materials definition of LT307(A)

			Availability					
Component	**Material**	**Mass %**	**Renewable**	**Non-renewable**	**Recycled post-industrial**	**Recycled post-consumer**	**Origin of raw materials**	**Supply Distance (miles)**
China body	Ceramic		No	Yes			Mexico	
Carton Box	Corrugated Board		No	Yes			Mexico	
Inserts	Corrugated Board		No	Yes			Mexico	
-	Remaining materials		No	Yes			Miscellaneous	
	TOTAL	**100%**						

Table A.2 Raw materials definition of LT569

			Availability					
Component	**Material**	**Mass %**	**Renewable**	**Non-renewable**	**Recycled post-industrial**	**Recycled post-consumer**	**Origin of raw materials**	**Supply Distance (miles)**
China body	Ceramic		No	Yes			Mexico	
Carton Box	Corrugated Board		No	Yes			Mexico	
Inserts	Corrugated Board		No	Yes			Mexico	
-	Remaining materials		No	Yes			Miscellaneous	
	TOTAL	**100%**						

Table A.3 LCI data for turning steel CNC process

Turning, steel, CNC, average	1	kg
This dataset encompasses the direct electricity consumption of the machine as well as compressed air and lubricant oil. Furthermore, the metal removed is included. Machine as well as factory infrastructure and operation are considered as well. The disposal of the lubricant oil is also included while the metal removed is assumed to be recycled. Geographical coverage encompasses the industrialized countries based on 2007 LCI data using industry average technology.		
Materials/fuels		
Electricity, low voltage, production	1.78	kWh
Compressed air, average installation, >30kW, 7 bar gauge, at supply network	1.28	m3
Lubricating oil, at plant	0.00382	kg
Metal working machine, unspecified, at plant	0.000174	kg
Metal working factory	2.02E-09	p
Metal working factory operation, average heat energy	4.41	kg
Steel, low-alloyed, at plant	1	kg
Emissions to air		
Heat, waste	6.39	MJ
Waste to treatment		
Disposal, used mineral oil, 10% water, to hazardous waste incineration	0.00382	kg

Table A.4 LCI data for cold impact extrusion, steel

Cold impact extrusion, steel	1	kg
This dataset encompasses the electricity consumption of the machine as well as common pre- and post-treatments. Furthermore, machine as well as factory infrastructure and operation are considered as well. Degreasing is not included and has to be added if necessary. Geographical coverage encompasses the industrialized countries Based on 2007 LCI data using industry average technology.		
Materials/fuel	-	-
Deformation stroke, cold impact extrusion, steel	1	kg
Surface treatment, cold impact extrusion, steel	1	kg
Heat treatment, cold impact extrusion, steel	1	kg
Compressed air, average installation, >30kW, 7 bar gauge, at supply network	0.291	m3
Metal working machine, unspecified, at plant	0.0000395	kg
Metal working factory	4.58E-10	p
Metal working factory operation, average heat energy	1	kg

APPENDIX B. ADDITIONAL RESULTS

No additional result views have been reported at this point.

APPENDIX C. IMPACT CATEGORIES

The impact assessment is based on the TRACI methodology and is reported in [Bare, 2011]. The contents of this publication are presented in this appendix. A definition of the impact categories within TRACI can be found at:
http://www.earthshift.com/software/simapro/traci2 [6].

APPENDIX D. USED DATASHEETS

To model the LCA different data sources have been used. This appendix includes a list of all datasheets that have been used. The list is included in separate spreadsheets "LCA of TOTO Lavatory Ceramics LCI-LCA modeling data and results 11-2015.xlsx", "TOTO Lavatory EN15804 LCI and LCIA 11-2015", and "TOTO Lavatory Waste LCIA 09-2015". A table of the data assessment is included in a separate spreadsheet titled "TOTO Lavatory Data Quality 11-2015"

APPENDIX E. LCI

The LCI results for all products are included in separate spreadsheets "LCA of TOTO Lavatory Ceramics LCI-LCA modeling data and results 11-2015.xlsx", "TOTO Lavatory EN15804 LCI and LCIA 11-2015", and "TOTO Lavatory Waste LCIA 09-2015".

APPENDIX F. LCIA METHOD

The LCIA characterization factors are included in separate spreadsheets "LCA of TOTO Lavatory Ceramics LCI-LCA modeling data and results 11-2015.xlsx", "TOTO Lavatory EN15804 LCI and LCIA 11-2015", and "TOTO Lavatory Waste LCIA 09-2015".

APPENDIX G. PROCESS FLOW DIAGRAMS

A process flow diagram of each product is included in a separate spreadsheet "LCA of TOTO Lavatory Ceramics LCI-LCA modeling data and results 11-2015.xlsx". The modeled materials and energy flows are presented.

APPENDIX H. IMPACTS PER 1 PRODUCT UNIT

The mass of LT307(A) is 18.7 kg and LT569 is 8.21 kg. The LCA model uses these masses to calculate impacts, although the functional unit for the modeled products is 1 ton. The tables below present impacts in terms of one product unit.

All impact tables presented in this report are present in the spreadsheet “TOTO Impacts Tables for Lavatory Report 11-2015”. Presented below, in tables H.1 and H.2, are the resource use, output flows and waste categories per 1 product unit. Also presented below, in tables H.3 and H.4, are TRACI impacts categorized by life cycle phase per 1 product unit.

Table H.1 Resource use, output flows and waste categories for LT307(A) by life cycle stage

Use of Resources													
		LT307(A)											
Parameter	**Unit**	**A1-A3**	**A4**	**A5**	**B1**	**B2**	**B3-B7**	**C1**	**C2**	**C3**	**C4**	**D**	**Total**
Use of renewable primary energy excluding the renewable primary energy resources used as raw	**MJ, calorific value** ([Hi] lower calorific value)	1.48E+01	1.19E-01	4.03E-03	0	2.13E+01	0	0	2.43E-03	7.01E-03	1.02E-02	-1.30E+00	3.49E+01
Use of renewable primary energy resources used as raw materials	**MJ, calorific value** ([Hi] lower calorific value)	5.72E+01	1.22E-02	1.60E-03	0	2.95E-01	0	0	2.48E-04	3.03E-03	4.90E-03	-4.91E+01	8.46E+00
Total use of renewable primary energy resources (primary energy and primary energy resources used as	**MJ, calorific value** ([Hi] lower calorific value)	7.20E+01	1.31E-01	5.64E-03	0	2.15E+01	0	0	2.68E-03	1.00E-02	1.51E-02	-5.04E+01	4.33E+01
Use of non-renewable primary energy excluding non-renewable primary energy resources used as	**MJ, calorific value** ([Hi] lower calorific value)	6.80E+02	1.00E+02	3.06E-01	0	1.90E+03	0	0	2.05E+00	3.41E-01	3.45E+00	-2.02E+01	2.67E+03
Use of non-renewable primary energy resources used as raw materials	**MJ, calorific value** ([Hi] lower calorific value)	0	0	0	0	0	0	0	0	0	0	0	0
Total use of non-renewable primary energy resources (primary energy and primary energy resources used as	**MJ, calorific value** ([Hi] lower calorific value)	6.80E+02	1.00E+02	3.06E-01	0	1.90E+03	0	0	2.05E+00	3.41E-01	3.45E+00	-2.02E+01	2.67E+03
Use of secondary material	**kg**	0	0	0	0	0	0	0	0	0	0	0	0
Use of renewable secondary fuels	**MJ, calorific value** ([Hi] lower calorific value)	0	0	0	0	0	0	0	0	0	0	0	0
Use of nonrenewable secondary fuels	**MJ, calorific value** ([Hi] lower calorific value)	0	0	0	0	0	0	0	0	0	0	0	0
Use of net fresh water*	**m3**	1.04E+02	6.61E-01	2.98E-02	0	1.76E+02	0	0	1.35E-02	3.80E-03	7.60E-02	-1.42E+01	2.67E+02
Output Material Flows													
		LT307(A)											
Parameter	**Unit**	**A1-A3**	**A4**	**A5**	**B1**	**B2**	**B3-B7**	**C1**	**C2**	**C3**	**C4**	**D**	**Total**
Hazardous waste disposed	**kg**	2.43E+01	1.53E-04	7.52E-04	0	1.77E+01	0	0	4.60E-06	5.30E-03	2.54E-03	-2.42E-01	4.18E+01
Non-hazardous waste disposed	**kg**	5.75E+00	3.14E-02	1.63E-02	0	6.11E+01	0	0	6.41E-04	1.73E-02	3.87E-02	-1.57E+00	6.54E+01
Radioactive waste disposed	**kg**	6.29E-02	7.90E-05	6.31E-05	0	2.10E-01	0	0	1.61E-06	2.24E-04	1.27E-04	-4.83E-03	2.69E-01
Waste Categories													
		LT307(A)											
Parameter	**Unit**	**A1-A3**	**A4**	**A5**	**B1**	**B2**	**B3-B7**	**C1**	**C2**	**C3**	**C4**	**D**	**Total**
Components for re-use	**kg**	0	0	0	0	0	0	0	0	0	0	0	0
Materials for recycling	**kg**	1.30E-02	0	0	0	0	0	0	0	0	0	1.18E+00	1.20E+00
Materials for energy recovery	**kg**	0	0	0	0	0	0	0	0	0	0	0	0
Exported energy	**MJ, heating value** ([Hi] lower heating value) **per energy carrier**	0	0	0	0	0	0	0	0	0	0	0	0

*Net fresh water consumption was calculated using the formula presented in UL Part A.

Table H.2 Resource use, output flows and waste categories for LT569 by life cycle stage

Use of Resources													
		LT569											
Parameter	**Unit**	**A1-A3**	**A4**	**A5**	**B1**	**B2**	**B3-B7**	**C1**	**C2**	**C3**	**C4**	**D**	**Total**
Use of renewable primary energy excluding the renewable primary energy resources used as raw materials	**MJ, calorific value** ([Hi] lower calorific value)	6.11E+00	5.23E-02	2.40E-03	0	2.13E+01	0	0	1.02E-03	4.05E-03	4.07E-03	-4.59E-01	2.70E+01
Use of renewable primary energy resources used as raw materials	**MJ, calorific value** ([Hi] lower calorific value)	3.28E+01	5.34E-03	9.53E-04	0	2.95E-01	0	0	1.05E-04	1.76E-03	1.95E-03	-2.92E+01	3.90E+00
Total use of renewable primary energy resources (primary energy and primary energy resources used as raw materials)	**MJ, calorific value** ([Hi] lower calorific value)	3.89E+01	5.77E-02	3.35E-03	0	2.15E+01	0	0	1.13E-03	5.81E-03	6.02E-03	-2.96E+01	3.09E+01
Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials	**MJ, calorific value** ([Hi] lower calorific value)	2.94E+02	4.40E+01	1.82E-01	0	1.90E+03	0	0	8.61E-01	1.71E-01	1.38E+00	-1.00E+01	2.23E+03
Use of non-renewable primary energy resources used as raw materials	**MJ, calorific value** ([Hi] lower calorific value)	0	0	0	0	0	0	0	0	0	0	0	0
Total use of non-renewable primary energy resources (primary energy and primary energy resources used as raw materials)	**MJ, calorific value** ([Hi] lower calorific value)	2.94E+02	4.40E+01	1.82E-01	0	1.90E+03	0	0	8.61E-01	1.71E-01	1.38E+00	-1.00E+01	2.23E+03
Use of secondary material	**kg**	0	0	0	0	0	0	0	0	0	0	0	0
Use of renewable secondary fuels	**MJ, calorific value** ([Hi] lower calorific value)	0	0	0	0	0	0	0	0	0	0	0	0
Use of nonrenewable secondary fuels	**MJ, calorific value** ([Hi] lower calorific value)	0	0	0	0	0	0	0	0	0	0	0	0
Use of net fresh water*	**m3**	4.10E+01	2.90E-01	1.77E-02	0	1.76E+02	0	0	5.68E-03	1.35E-03	3.03E-02	-4.82E+00	2.13E+02
Output Material Flows													
		LT569											
Parameter	**Unit**	**A1-A3**	**A4**	**A5**	**B1**	**B2**	**B3-B7**	**C1**	**C2**	**C3**	**C4**	**D**	**Total**
Hazardous waste disposed	**kg**	4.82E+00	9.89E-05	4.47E-04	0	1.77E+01	0	0	1.93E-06	8.23E-04	1.02E-03	-8.75E-02	2.24E+01
Non-hazardous waste disposed	**kg**	1.45E+00	1.38E-02	9.71E-03	0	6.11E+01	0	0	2.70E-04	9.77E-03	1.54E-02	-7.38E-01	6.18E+01
Radioactive waste disposed	**kg**	1.62E+01	3.47E-05	3.75E-05	0	2.10E-01	0	0	6.79E-07	1.32E-04	5.08E-05	-2.44E-03	1.64E+01
Waste Categories													
		LT569											
Parameter	**Unit**	**A1-A3**	**A4**	**A5**	**B1**	**B2**	**B3-B7**	**C1**	**C2**	**C3**	**C4**	**D**	**Total**
Components for re-use	**kg**	0	0	0	0	0	0	0	0	0	0	0	0
Materials for recycling	**kg**	6.11E-03	0	0	0	0	0	0	0	0	0	6.89E-01	6.96E-01
Materials for energy recovery	**kg**	0	0	0	0	0	0	0	0	0	0	0	0
Exported energy	**MJ, heating value** ([Hi] lower heating value) **per energy carrier**	0	0	0	0	0	0	0	0	0	0	0	0

*Net fresh water consumption was calculated using the formula presented in UL Part A.

Table H.3 Life cycle impacts for LT307(A) – absolute results

Impact category	Unit	Production [A1-A3]	Construction [A4,A5]	Use [B2]	End of life [C2- C4]	Recovery [D]	Total
Ecological damage							
Acidification	SO_2 eq	1.22E-01	4.82E-02	1.42E+00	2.28E-03	-1.33E-02	1.58E+00
Ecotoxicity	CTUe	3.66E+01	1.97E+01	1.03E+02	5.12E-01	-4.17E+00	1.56E+02
Eutrophication	N eq (nitrogen)	1.45E-02	3.96E-03	1.14E-01	2.13E-04	-2.61E-03	1.30E-01
Global warming	CO_2 eq (carbon dioxide)	3.89E+01	8.61E+00	1.03E+02	3.32E-01	-1.42E+00	1.49E+02
Ozone depletion	CFC-11 eq	5.19E-06	4.52E-09	6.79E-06	5.56E-08	-1.15E-07	1.19E-05
Human health damage							
Carcinogenics	CTUh	1.35E-06	1.06E-07	1.78E-06	5.80E-09	-3.27E-07	2.91E-06
Non-carcinogenics	CTUh	3.75E-06	1.02E-06	1.20E-05	4.70E-08	-5.73E-07	1.62E-05
Respiratory effects	PM2.5 eq	1.28E-02	8.72E-04	1.20E-01	1.86E-04	-2.40E-03	1.31E-01
Smog	O_3 eq (ozone)	2.21E+00	1.32E+00	6.13E+00	6.13E-02	-1.60E-01	9.56E+00
Resource depletion							
Fossil fuel depletion	MJ surplus	7.98E+01	1.40E+01	2.04E+02	7.87E-01	-1.57E+00	2.97E+02

Table H.4 Life cycle impacts for LT569 – absolute results

Impact category	Unit	Production [A1-A3]	Construction [A4,A5]	Use [B2]	End of life [C2- C4]	Recovery [D]	Total
Ecological damage							
Acidification	SO2 eq	5.75E-02	2.12E-02	1.42E+00	9.68E-04	-6.80E-03	1.50E+00
Ecotoxicity	CTUe	1.66E+01	8.66E+00	1.03E+02	2.23E-01	-1.42E+00	1.27E+02
Eutrophication	N eq (nitrogen)	7.60E-03	1.91E-03	1.14E-01	9.52E-05	-1.48E-03	1.22E-01
Global warming	CO2 eq (carbon dioxide)	1.71E+01	3.90E+00	1.03E+02	1.40E-01	-6.99E-01	1.23E+02
Ozone depletion	CFC-11 eq	2.19E-06	2.41E-09	6.79E-06	2.27E-08	-6.33E-08	8.94E-06
Human health damage							
Carcinogenics	CTUh	5.28E-07	4.68E-08	1.78E-06	2.78E-09	-1.05E-07	2.25E-06
Non-carcinogenics	CTUh	2.16E-06	4.49E-07	1.20E-05	2.27E-08	-2.02E-07	1.44E-05
Respiratory effects	PM2.5 eq	5.70E-03	3.85E-04	1.20E-01	8.42E-05	-1.03E-03	1.25E-01
Smog	O3 eq (ozone)	9.87E-01	5.81E-01	6.13E+00	2.59E-02	-8.65E-02	7.63E+00
Resource depletion							
Fossil fuel depletion	MJ surplus	3.41E+01	6.14E+00	2.04E+02	3.24E-01	-8.15E-01	2.44+E02

APPENDIX I. SUSTAINABLE MINDS CUSTOM IMPACT FACTORS

Normalization and weighting

To arrive to the single score indicator, normalization[3] and weighting[4] conforming to Sustainable Minds (SM) Part A[5] of the Framework was applied. The Sustainable Minds indicator expressed in millipoints is a part of the SM reporting requirements. It is important to note, however, that the indicator is not only based on scientific impact assessment and normalization, but also on weighting which is based on expert judgment. This last step is a value judgment and can change between different experts and will likely change over time since environmental priorities change over time. This change is not annual but rather it takes a decade. With the limited validation of any LCA and the 3 years validity of a Transparency Report, any changes in these value judgments will be reflected in future updates.

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[3] A. Lautier, et al. (2010). Development of normalization factors for Canada and the United States and comparison with European factors. Science of the Total Environment. 409: 33-42.

[4] Bare, Jane; Gloria, Tom and Norris, Greg, Development of the Method and U.S. Normalization Database fro Life Cycle Impact Assessment and Sustainability Metrics, Environmental Science and Technology, / VOL. 40, NO. 16, 2006

[5] Sustainable Minds Transparency Report™ Framework, Part A: LCA calculation rules and report requirements. Version 2015, February 2015.

Table 9.2a Normalization and Weighting factors

Impact category	Normalization	Weighting (%)
Ozone depletion	6.20	2.4
Smog	7.18E-4	4.8
Acidification	1.10E-2	3.6
Fossil fuel depletion	5.79E-5	12.1
Eutrophication	4.63E-2	7.2
Respiratory effects	4.12E-2	10.8
Non carcinogenics	952	6.0
Carcinogenics	19,706	9.6
Ecotoxicity	9.05E-5	8.4
Global warming	4.13E-5	34.9

SM results

The SM millipoint score by life cycle phase for the products is presented below (Tables 9.2b and 9.2c). They confirm the trends in the results using the impact assessment results before normalization and weighting except in the recovery stage.

Table 9.2b SM millipoint scores for LT307(A) by life cycle phase – absolute results

Impact category	Unit	Total	Production [A1-A3]	Construction [A4,A5]	Use [B2]	End of life [C2- C4]	Recovery [D]
SM single figure	mPts	13.83	4.40	0.71	9.43	0.03	-0.74

Table 9.2c SM millipoint scores for LT569 by life cycle phase – absolute results

Impact category	Unit	Total	Production [A1-A3]	Construction [A4,A5]	Use [B2]	End of life [C2- C4]	Recovery [D]
SM single figure	mPts	11.35	1.84	0.32	9.43	0.01	-0.25