Declaration Owner

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Product

CLEO Flooring

Functional Unit

The functional unit is one square meter of floor covering provided and maintained for a period of 60 years.

EPD Number and Period of Validity

SCS-EPD-05530
EPD Valid May 22, 2019 through May 21, 2024

Product Category Rule

Product Category Rule (PCR) for preparing an Environmental Product Declaration (EPD) for Flooring: Carpet, Resilient, Laminate, Ceramic, Wood. NSF International. Version 2. 2014.

Program Operator

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Disclaimers: *This EPD conforms to ISO 14025, 14040, ISO 14044, and ISO 21930.*

Scope of Results Reported: *The PCR requirements limit the scope of the LCA metrics such that the results exclude environmental and social performance benchmarks and thresholds, and exclude impacts from the depletion of natural resources, land use ecological impacts, ocean impacts related to greenhouse gas emissions, risks from hazardous wastes and impacts linked to hazardous chemical emissions.*

Accuracy of Results: *Due to PCR constraints, this EPD provides estimations of potential impacts that are inherently limited in terms of accuracy.*

Comparability: *The PCR this EPD was based on was not written to support comparative assertions. EPDs based on different PCRs, or different calculation models, may not be comparable. When attempting to compare EPDs or life cycle impacts of products from different companies, the user should be aware of the uncertainty in the final results, due to and not limited to, the practitioner's assumptions, the source of the data used in the study, and the specifics of the product modeled.*

PCR review, was conducted by	Jack Geibig, EcoForm. jgeibig@ecoform.com
Approved Date: May 22, 2019 – End Date: May 21, 2024	
Independent verification of the declaration and data, according to ISO 14025:2006 and ISO 21930:2007.	☐ internal ☑ external
Third party verifier	Tom Gloria, PhD, Industrial Ecology Consultants

ABOUT CONGOLEUM CORPORATION

Since 1886 Congoleum Corporation has been committed to developing innovative flooring products that push the industry forward. Congoleum holds numerous patents for novel creations over the years, and these patents have resulted in products that are like no others in the industry.

Congoleum manufactures residential and commercial resilient products that are engineered with state-of-the-art manufacturing equipment in New Jersey and Pennsylvania and that demonstrate Congoleum's quality and design leadership. With more than 5,000 retailers selling Congoleum products across North America, Congoleum is proud of its strong and iconic past, energized by the future and as always, unwavering in its commitment to quality, design and innovation.

PRODUCT DESCRIPTION

The CLEO flooring products are used in various interior residential and commercial applications including retail, healthcare, education, and hospitality. CLEO flooring is U.S. made with 85% limestone. CLEO's eco-forward construction contains zero pvc, plasticizers, and phthalates and has ultralow VOCs. Using a patented omni construction process, CLEO is constructed on a flexible, waterproof Mineral Composite Core.

CLEO's patterns are created using ChromaTru™ solvent-free digital printing, with no pvc-containing print film. This provides stunningly realistic designs and is protected by our UltraClear™ high-performance system: two cross-linked urethane coatings that provide UV stability and excellent scratch and wear resistance. The topmost coating is a special enhanced urethane with outstanding stain resistance and washability.

CLEO has been awarded NSF/ANSI 332 Platinum Level Certification and is certified as **asthma & allergy friendly®** by the Asthma and Allergy Foundation of America. CLEO is certified under FloorScore®, is CHPS 01350 compliant and contributes to satisfying the low emitting materials credit under LEED. CLEO can contribute points under the National Green Building Standard (NAHB) ICC/ASHRAE-700-2015.

PRODUCT APPLICATION

CLEO flooring is currently suitable for residential applications.

PRODUCT PERFORMANCE

Table 1. Product performance test results for CLEO flooring.

Test Method	Test Description	Specification	Test Results
ASTM F2055	Size Tolerance	± 0.016 "/lf (1.33 mm/m)	Pass
ASTM F386	Thickness Tolerance	as spec ± 0.005" (spec =0.160")	Pass
ASTM F2055	Squareness	< 0.010"/lf (0.833 mm/m)	Pass
ASTM F925	Resistance to Chemicals	no more than slight change	Pass
ASTM F1515	Resistance to Light	ΔE < 8	Pass
ASTM F1514	Resistance to Heat	ΔE < 8	Pass
ASTM F970	Static Load	< 0.005" (0.127 mm) after 24 h recovery	Pass

MATERIAL CONTENT

Table 2. Origin and availability of material content for CLEO flooring.

Component	Materials	Origin of Raw Material	Availability			Pre- and Post-Consumer Recycled Content	Percent of Total Mass
			Renewable	Non-Renewable	Recycled		
CLEO Flooring							
Mineral filler	Dolomitic limestone	US	Mineral, Abundant				85%
Ethylene-based polymer	Ethylene-based polymer	Global		Fossil, Limited			11%
Hydrocarbon resin	Hydrocarbon resin	US		Fossil, Limited			2.9%
Wear/puncture resistance layer	Coating	Global		Fossil, Limited			0.97%
Surface smoothing layer	Coating	Global		Fossil, Limited			0.10%
Print fidelity layer	Coating	US		Fossil, Limited			0.60%
Scratch resistance layer	Coating	US		Fossil, Limited			0.12%
Decoration	Ink	Global		Fossil, Limited			0.07%
Packaging							
Packaging	Corrugated board	Global	Abundant		Abundant	0%/100%	48%
Packaging	Wood pallet	Global	Abundant		Abundant	0%/100%	52%

Chemicals listed as hazardous by regulatory agencies are not components of CLEO flooring.
The trace amounts of the chemicals listed below are encapsulated in the final CLEO product.

Component	Materials	Origin of Raw Material	Availability			Pre- and Post-Consumer Recycled Content	Percent of Total Mass
			Renewable	Non-Renewable	Recycled		
Carbon Black	Decoration	Global	Global		Fossil, Limited		0.0016%
Diethylene glycol diethyl ether	Decoration	Global	Global		Fossil, Limited		0.000073%
Hexamethylene-1,6-diisocyanate	Wear/puncture resistance layer, Surface smoothing layer	Global	Global		Fossil, Limited		0.0011%
Quartz	Mineral filler	US	US	Mineral, Abundant			0.85%
Toluene	Decoration	Global	Global		Fossil, Limited		0.000044%

PRODUCTION OF MAIN MATERIALS

Dolomitic Limestone (Calcium Carbonate): An abundant mineral found worldwide and a common substance found in rocks. It can be ground into varying particle sizes and used as inert filler.

Ethylene –based Polymer: A thermoplastic prepared by the polymerization of vinyl acetate monomer, derived from petrochemicals.

Hydrocarbon (Petroleum) Resin: Hydrocarbon resin is a kind of thermal plasticizing hydrocarbon resin produced by C5, C9 fraction, by-products of petroleum cracking, through pretreatment, polymerization and distillation. Generally, the petroleum resins are not used independently, but are used together with other kinds of resins as promoters, adjusting agents and modifiers in industrial applications.

Bonding Components: Used to ensure bonding of the inks and coatings to the backing and derived from petrochemicals.

UV Sealer (Coating): A UV coating composed of photo-curable oligomer, photo initiator, reactive acrylic monomer and additives. It has excellent adhesion to substrate and is a UV coating which provides scratch resistance, crack resistance, chemical resistance and abrasion resistance.

PRODUCT CHARACTERISTICS

Table 3. Product characteristics for the CLEO flooring.

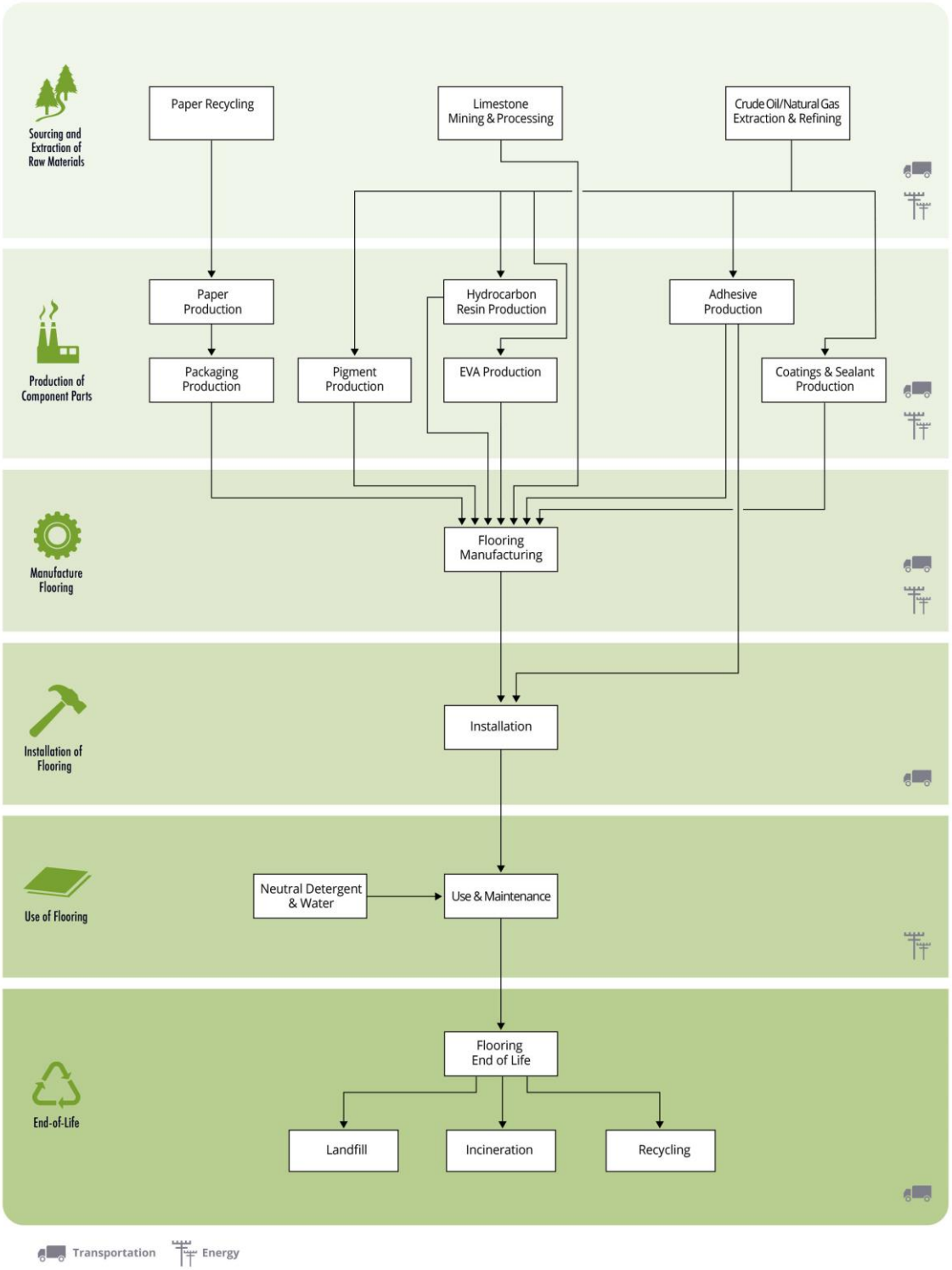
Characteristics		Average Value	Unit	Minimum Value	Maximum Value
Product Thickness		4.1 (0.16)	mm (in)	3.9 (0.16)	4.2 (0.16)
Wear Layer Thickness		0.10 (0.004)	mm (in)	0.08 (0.003)	0.13 (0.005)
Product Weight		0.81 (27)	g/cm2 (oz/ft2)	0.73 (24)	0.88 (29)
Product Form (Tiles)	Width	610 (24)	mm (in)	610 (24)	1524 (60)
	Length	610 (24)	mm (in)	178 (7.0)	610 (24)
VOC Emissions Test Method		FloorScore®			
Sustainable Certifications		NSF 332 Platinum			

LIFE CYCLE ASSESSMENT

A cradle to grave life cycle assessment (LCA) was completed for this product group in accordance with ISO 14040, ISO 14044, ISO 21930, and Product Category Rule for Environmental Product Declarations for Flooring: Carpet, Resilient, Laminate, Ceramic, Wood (Version 2).

PRODUCT LIFE CYCLE FLOW DIAGRAM

The diagram below is a representation of the most significant contributions to the life cycle of CLEO flooring. This includes resource extraction and processing, product manufacture, use and maintenance, and end-of-life.



FUNCTIONAL UNIT

The functional unit is, according to the PCR, the total impact for the expected life of the building (60 years). But the service life is dependent on the product lifetime, which is 15 years in this case. The PCR consequently requires separate reporting of LCA results A) for 1 m^2 of floor covering - extraction/processing, manufacturing, delivery and installation and end of life, B) the average 1- year use stage, and C) for the 60 year life of the building as combined using A) and B), calculated from the reference service life (RSL) of the product.

LIFE CYCLE ASSESSMENT STAGES AND REPORTED INFORMATION

Sourcing/Extraction Stage (raw material acquisition)

This stage includes extraction of virgin materials and reclamation of non-virgin feedstock. Resource use and emissions associated with both extraction of the raw materials and manufacture of carpet components are included.

Manufacturing Stage

CLEO flooring is manufactured in Hamilton Township, New Jersey. The facility is not certified to ISO 9001 or ISO 14001.

This stage includes all the relevant manufacturing processes and flows, including packaging. Production of capital goods, infrastructure, production of manufacturing equipment, and personnel-related activities are not included.

Delivery and Installation Stage

Delivery

This stage includes the delivery of the flooring product to the point of installation. Modeling used in the life cycle assessment assumed an estimated distribution distance to point of approximately 1,100 km via diesel truck.

Installation

CLEO flooring is installed with *Congoleum DS 100 Pressure Sensitive Adhesive* as recommended, or a similar adhesive. The recommended application rate is 200 - 250 $ft.^2$/gal (0.204 – 0.163 kg/m^2).

Waste

Waste generated during product installation can be disposed of in a landfill, incinerated, or recycled.

Packaging

Table 4. Packaging material for the CLEO flooring. Values are shown per 1 m^2 flooring.

Material	CLEO Flooring	
	Amount (kg)	Percent of Total
Corrugated board	0.14	48%
Wood pallet	0.15	52%

Use Stage

Cleaning and maintenance

Table 5. Cleaning and maintenance for the CLEO flooring

Cleaning Process	Cleaning and Maintenance Frequency	Frequency over 15 year Reference Service Life (RSL)	Energy & Resource Use
Dust mop	Weekly (52 d/y)	3,120 times	None
Damp mop / neutral cleaner	Weekly (52 d/y)	3,120 times	Hot water; neutral cleaner

End-of-Life Stage

Recycling, reuse, or repurpose

Data for estimation of recycling rates for the product and packaging are taken from 2014 statistics regarding municipal solid waste generation and disposal in the United States, from the US Environmental Protection Agency.

For disposal of product materials which are not recycled, it is assumed that 20% are incinerated and 80% go to a landfill. Transportation of waste materials at end of life assumes a 20 mile average distance to disposal, consistent with assumptions used in the US EPA WARM model.

LIFE CYCLE INVENTORY

In accordance with ISO 21930, the following aggregated inventory flows are included in the LCA, in addition to the LCIA and inventory flow requirements specified by the PCR:

- Use of renewable material resources
- Consumption of freshwater
- Hazardous Waste
- Non-hazardous Waste

All results are calculated using the SimaPro 8.3 model using primary and secondary inventory data. Classification for

Use of Renewable Material Resources is based on review of elementary flows and resources considered renewable on a human time scale. Elementary flows related to use of wood, minerals, and land occupation were not included. Water consumption is also not included as this is reported separately. Based on this classification process, no renewable material resources are estimated for the product system under consideration.

Table 6. Results for aggregated inventory flows, shown in kg per 1 m^2 of flooring maintained for 60 years.

Parameter	CLEO Flooring	Unit
Freshwater consumption	2,700	kg
Hazardous wastes	$7.6x10^{-4}$	kg
Non-hazardous wastes	44	kg

LIFE CYCLE IMPACT ASSESSMENT

Life cycle impact assessment is the process of converting the life cycle inventory results into a representation of environmental and human health impacts. For example, emissions such as carbon dioxide, methane, and nitrous oxide (inventory) together contribute to climate change (impact assessment). The impact assessment for the EPD is conducted in accordance with requirements of the PCR. Impact category indicators are estimated using the CML (2013) characterization method. Aggregated inventory flows for energy use and wastes are also calculated. The LCIA and inventory flow results are calculated using SimaPro 8.3 software.

Table 7. *Cradle-to-install and end-of-life for CLEO flooring. Results are shown per 1 m^2 flooring for an average 1-year time horizon. (Table A of the PCR)*

Impact Category	Units	Extraction & Processing	Manufacturing	Delivery & Installation	Disposal	Total
Global Warming Potential, 100 year time horizon	kg CO_2 eq	4.7 24%	6.3 32%	2.0 10%	6.4 33%	19 100%
Acidification Potential	kg SO_2 eq	$2.0x10^{-2}$ 27%	$4.2x10^{-2}$ 58%	$8.5x10^{-3}$ 12%	$2.1x10^{-3}$ 2.9%	$7.2x10^{-2}$ 100%
Eutrophication Potential	kg PO_4^{3-} eq	$5.2x10^{-3}$ 13%	$8.4x10^{-3}$ 21%	$2.0x10^{-3}$ 5.1%	$2.4x10^{-2}$ 61%	$4.0x10^{-2}$ 100%
Photochemical Ozone Creation Potential	kg C_2H_4	$1.4x10^{-3}$ 28%	$1.9x10^{-3}$ 40%	$4.5x10^{-4}$ 9.3%	$1.1x10^{-3}$ 23%	$4.9x10^{-3}$ 100%
Ozone Depletion Potential	kg CFC-11 eq	$3.1x10^{-7}$ 28%	$4.1x10^{-7}$ 37%	$3.4x10^{-7}$ 31%	$4.6x10^{-8}$ 4.2%	$1.1x10^{-6}$ 100%
Abiotic Depletion Potential, Elements	kg Sb eq	$1.1x10^{-5}$ 55%	$1.9x10^{-6}$ 10%	$6.6x10^{-6}$ 33%	$4.5x10^{-7}$ 2.3%	$2.0x10^{-5}$ 100%
Abiotic Depletion Potential, Fossil Fuels	MJ	120 50%	81 34%	33 14%	4.5 1.9%	240 100%
Renewable Energy	MJ	120 40%	140 47%	34 11%	4.8 1.5%	310 100%
Non-renewable Energy	MJ	2.8 38%	3.7 51%	0.60 8.3%	0.19 2.6%	7.3 100%

Table 8. *Average 1 year use stage impacts for CLEO flooring per 1 m^2 flooring. (Table B of the PCR)*

Impact Category	Units	Use & Maintenance
Global Warming Potential, 100 year time horizon	kg CO_2 eq	$5.5x10^{-2}$
Acidification Potential	kg SO_2 eq	$3.4x10^{-4}$
Eutrophication Potential	kg PO_4^{3-} eq	$1.0x10^{-4}$
Photochemical Ozone Creation Potential	kg C_2H_4	$1.8x10^{-5}$
Ozone Depletion Potential	kg CFC-11 eq	$3.2x10^{-9}$
Abiotic Depletion Potential, Elements	kg Sb eq	$1.4x10^{-7}$
Abiotic Depletion Potential, Fossil Fuels	MJ	0.84
Renewable Energy	MJ	0.99
Non-renewable Energy	MJ	$9.7x10^{-2}$

Table 9. *Life cycle stage impacts for CLEO flooring per 1 m^2 flooring over an average building life of 60 years. (Table C of the PCR)*

Impact Category	Units	Extraction & Processing	Manufacturing	Delivery & Installation	Use	Disposal	Total
Global Warming Potential, 100 year time horizon	kg CO_2 eq	19 23%	25 31%	7.9 9.8%	3.3 4.1%	26 32%	81 100%
Acidification Potential	kg SO_2 eq	$7.8x10^{-2}$ 25%	0.17 54%	$3.4x10^{-2}$ 11%	$2.0x10^{-2}$ 7%	$8.2x10^{-3}$ 2.7%	0.31 100%
Eutrophication Potential	kg PO_4^{3-} eq	$2.1x10^{-2}$ 13%	$3.4x10^{-2}$ 20%	$8.1x10^{-3}$ 4.9%	$6.3x10^{-3}$ 3.8%	$9.6x10^{-2}$ 58%	0.17 100%
Photochemical Ozone Creation Potential	kg C_2H_4	$5.5x10^{-3}$ 27%	$7.7x10^{-3}$ 38%	$1.8x10^{-3}$ 8.8%	$1.1x10^{-3}$ 5%	$4.4x10^{-3}$ 21%	$2.1x10^{-2}$ 100%
Ozone Depletion Potential	kg CFC-11 eq	$1.2x10^{-6}$ 27%	$1.6x10^{-6}$ 36%	$1.3x10^{-6}$ 29%	$1.9x10^{-7}$ 4.3%	$1.8x10^{-7}$ 4.0%	$4.6x10^{-6}$ 100%
Abiotic Depletion Potential, Elements	kg Sb eq	$4.4x10^{-5}$ 50%	$7.6x10^{-6}$ 8.7%	$2.6x10^{-5}$ 30%	$8.2x10^{-6}$ 9%	$1.8x10^{-6}$ 2.1%	$8.8x10^{-5}$ 100%
Abiotic Depletion Potential, Fossil Fuels	MJ	480 48%	320 32%	130 13%	50 5%	18 1.8%	1,000 100%
Renewable Energy	MJ	11 32%	15 42%	2.4 6.9%	5.8 17%	0.77 2.2%	35 100%
Non-renewable Energy	MJ	500 39%	580 45%	140 11%	59 4.6%	19 1.5%	1,300 100%

SUPPORTING TECHNICAL INFORMATION

Unit processes are developed with SimaPro 8.3 software, drawing upon data from multiple sources. Primary data were provided by Congoleum for their manufacturing processes. The primary sources of secondary LCI data are from Ecoinvent Database.

Table 10. *Data sources used for the LCA study.*

Component	Material Description	Material Dataset	Data Source	Publication Date
Product				
Mineral filler	Dolomitic limestone	Limestone, crushed, washed {RoW}| market for limestone, crushed, washed | Alloc Rec	EI v3.3	2016
Ethylene-based polymer	Ethylene-based polymer	Ethylene vinyl acetate copolymer {GLO} | market for | Alloc Rec	EI v3.3	2016
Hydrocarbon resin	Hydrocarbon resin	Dicyclopentadiene based unsaturated polyester resin {GLO}| market for | Alloc Rec	EI v3.3	2016
Wear/puncture resistance layer	Coating	Chemical, organic {GLO}| market for | Alloc Rec	EI v3.3	2016
Surface smoothing layer	Coating	Chemical, organic {GLO}| market for | Alloc Rec	EI v3.3	2016
Print fidelity layer	Coating	Chemical, organic {GLO}| market for | Alloc Rec	EI v3.3	2016
Scratch resistance layer	Coating	Chemical, organic {GLO}| market for | Alloc Rec	EI v3.3	2016
Decoration	Ink	Chemical, organic {GLO}| market for | Alloc Rec	EI v3.3	2016
Packaging				
Packaging	Corrugated board	Corrugated board, recycling fibre, double wall, at plant /RER	EI v2.2	2010
Packaging	Wood pallet	Wood pallet (Recycled) {GLO} | Alloc Rec	EI v2.2	2010
Transportation				
Road transport	Diesel Truck	Transport, freight, lorry 16-32 metric ton, EURO4 {GLO}| market for | Alloc Rec	EI v3.3	2016
Rail transport	Freight train	Transport, freight train {US}| market for | Alloc Rec	EI v3.3	2016
Ship transport	Transoceanic Ship	Transport, freight, sea, transoceanic ship {GLO}| market for | Alloc Rec	EI v3.3	2016

Data Quality

Table 11. *Data quality assessment for the LCA study.*

Data Quality Parameter	Data Quality Discussion
Time-Related Coverage: Age of data and the minimum length of time over which data is collected	The most recent available data are used, based on other considerations such as data quality and similarity to the actual operations. Typically, these data are less than 10 years old (typically 2016). All of the secondary data used represented an average of at least one year's worth of data collection, and up to three years in some cases. Manufacturer-supplied data (primary data) are based on annualized production for 2016 and engineering estimates.
Geographical Coverage: Geographical area from which data for unit processes is collected to satisfy the goal of the study	The data used in the analysis provide the best possible representation available with current data. Electricity use for product manufacture is modeled using representative data for the RFCE eGRID electricity grid mix. Surrogate data used in the assessment are representative of North American or global operations. Data representative of global operations are considered sufficiently similar to actual processes. Data representing product disposal are based on US statistics.
Technology Coverage: Specific technology or technology mix	For the most part, data are representative of the actual technologies used for processing, transportation, and manufacturing operations. Representative datasets are used to represent the actual processes, as appropriate.
Precision: Measure of the variability of the data values for each data expressed	Precision of results are not quantified due to a lack of data. Secondary data for operations are typically averaged for one or more years and over multiple operations, which is expected to reduce the variability of results.
Completeness: Percentage of flow that is measured or estimated	The LCA model included all known mass and energy flows for production of the flooring products. In some instances, surrogate data used to represent upstream and downstream operations may be missing some data which is propagated in the model. No known processes or activities contributing to more than 1% of the total environmental impact for each indicator are excluded. In total, these missing data represent less than 5% of the mass or energy flows.
Representativeness: Qualitative assessment of the degree to which the data set reflects the true population of interest	Data used in the assessment represent typical or average processes as currently reported from multiple data sources, and are therefore generally representative of the range of actual processes and technologies for production of these materials. Considerable deviation may exist among actual processes on a site-specific basis; however, such a determination would require detailed data collection throughout the supply chain back to resource extraction.
Consistency: Qualitative assessment of whether the study methodology is applied uniformly to the various components of the analysis	The consistency of the assessment is considered to be high. Data sources of similar quality and age are used; with a bias towards Ecoinvent v3.3 data where available. Different portions of the product life cycle are equally considered; however, it must be noted that final disposition of the product is based on assumptions of current average practices in the United States.
Reproducibility: Qualitative assessment of the extent to which information about the methodology and data values would allow an independent practitioner to reproduce the results reported in the study	Based on the description of data and assumptions used, this assessment would be reproducible by other practitioners. All assumptions, models, and data sources are documented.
Sources of the Data: Description of all primary and secondary data sources	Data representing energy use at Congoleum's New Jersey facility represent an annual average and are considered of medium to high quality due to the length of time over which these data are collected for the existing production processes. Planed production line energy use is based on engineering estimates that may not accurately reflect fluctuations in production and are subject to updates and revisions. For secondary LCI datasets, Ecoinvent v2.2 and v3.3 LCI data are used, with a bias towards Ecoinvent v3.3 data.
Uncertainty of the Information: Uncertainty related to data, models, and assumptions	Uncertainty related to materials in the flooring products and packaging is low. Actual supplier data for upstream operations was not available and the study relied upon the use of existing representative datasets. These datasets contained relatively recent data (<10 years), but lacked geographical representativeness. Uncertainty related to the impact assessment methods used in the study are high. The impact assessment method required by the PCR includes impact potentials, which lack characterization of providing and receiving environments or tipping points.

Allocation

Resource use at the manufacturing facilities in Hamilton Township, New Jersey (e.g., water and energy) was allocated to the product based on product mass.

The flooring product system includes recycled materials, which are allocated using the recycled content allocation method (also known as the 100-0 cut off method). Using the recycled content allocation approach, system inputs with recycled content do not receive any burden from the previous life cycle other than reprocessing of the waste material. At end of life, materials which are recycled leave the system boundaries with no additional burden.

Impacts from transportation were allocated based on the mass of material and distance transported.

System boundaries

The system boundary of the life cycle assessment for CLEO flooring products was cradle-to-grave. The system boundaries for this study are as follows:

- **Sourcing/extraction stage –** This stage includes extraction of virgin materials and reclamation of non-virgin feedstock. Resource use and emissions associated with both extraction of the raw materials product component manufacturing are included. Upstream transportation is also included.
- **Manufacturing stage –** This stage includes all the relevant manufacturing processes and flows, including packaging. Production of capital goods, infrastructure, production of manufacturing equipment, and personnel related activities are not included.
- **Delivery and installation stage –** This stage includes the delivery of the vinyl tile products to the point of installation.
- **Use stage –** The use stage includes the cleaning and maintenance of the floor covered during its lifetime, as well as extraction, manufacturing and transport of all sundry material for maintenance and cleaning.
- **End-of-life stage –** The end-of-life stage includes the transport of the floor covering to end of life processes including landfill, incineration, and recycling.

Cut-off criteria

According to the PCR, processes contributing greater than 1% of the total environmental impact indicator for each impact must be included in the inventory. In the present study, except as noted, all known materials and processes were included in the life cycle inventory.

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