ENVIRONMENTAL PRODUCT DECLARATION

DUCT LINER

LINACOUSTIC® RC • LINACOUSTIC® RC-HP • DUCT LINER PM

Think JM.

Linacoustic® RC/RC-HP is a fiber glass duct liner used to improve thermal and acoustical performance in metal ducts. Above: Fabricated Linacoustic RC/RC-HP and Linacoustic RC/RC-HP roll, manufactured in Cleburne, Texas

Johns Manville
A Berkshire Hathaway Company

At Johns Manville, product performance and corporate accountability are top priorities. We ensure that each of our HVAC insulation products not only performs but also contributes to the health, safety, and sustainability of the environments where they are used.

We strive to ensure that our products meet the rigorous demands of their applications while focusing on finding new ways to reduce our environmental footprint. We want to provide you with reliable materials that will allow you to do the same.

As a company, we are committed to evolving to help create a sustainable world for our future. When it comes to making decisions about your environmental impact, don't think just insulation, think JM.

PEOPLE • PASSION • PERFORM • PROTECT

UL CERTIFIED ENVIRONMENTAL PRODUCT DECLARATION UL.COM/EPD

Johns Manville

Duct Liner – Linacoustic® RC • Linacoustic® RC-HP • Duct Liner PM
Product Category: Mechanical Insulation

According to ISO 14025

This declaration is an environmental product declaration (EPD) in accordance with ISO 14025. EPDs rely on Life Cycle Assessment (LCA) to provide information on a number of environmental impacts of products over their life cycle. Exclusions: EPDs do not indicate that any environmental or social performance benchmarks are met, and there may be impacts that they do not encompass. LCAs do not typically address the site-specific environmental impacts of raw material extraction, nor are they meant to assess human health toxicity. EPDs can complement but cannot replace tools and certifications that are designed to address these impacts and/or set performance thresholds – e.g. Type 1 certifications, health assessments and declarations, environmental impact assessments, etc. Accuracy of Results: EPDs regularly rely on estimations of impacts, and the level of accuracy in estimation of effect differs for any particular product line and reported impact. Comparability: EPDs are not comparative assertions and are either not comparable or have limited comparability when they cover different life cycle stages, are based on different product category rules or are missing relevant environmental impacts. EPDs from different programs may not be comparable.

PROGRAM OPERATOR	UL Environment
DECLARATION HOLDER	Johns Manville
DECLARATION NUMBER	4787305280.101.1
DECLARED PRODUCT	Duct Liner
REFERENCE PCR	Building Envelope Thermal Insulation, Mechanical Insulation (v1.3, June 2014)
DATE OF ISSUE	December 15, 2016
PERIOD OF VALIDITY	5 Years
CONTENTS OF THE DECLARATION	Product definition and information about building physics Information about basic material and the material's origin Description of the product's manufacture Indication of product processing Information about the in-use conditions Life cycle assessment results Testing results and verifications

The PCR review was conducted by:	UL Environment PCR Review Panel epd@ulenvironment.com
This declaration was independently verified in accordance with ISO 14025 by Underwriters Laboratories ☐ INTERNAL ☒ EXTERNAL	[signature] Wade Stout, UL Environment
This life cycle assessment was independently verified in accordance with ISO 14044 and the reference PCR by:	[signature] Thomas P. Gloria, Industrial Ecology Consultants

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Product Definition

Company Description

For more than 150 years, Johns Manville (JM) has been dedicated to providing products that improve energy efficiency, and contribute to the health and comfort of building occupants.

We manufacture premium-quality building and mechanical insulation, commercial roofing, glass fibers and nonwoven materials for commercial, industrial and residential applications. JM products are used in a wide variety of industries including building products, aerospace, automotive and transportation, filtration, commercial interiors, waterproofing and wind energy.

JM employs 7,000 people globally and provides products to more than 85 countries. We operate 44 manufacturing facilities in North America, Europe, and China. Since 1988, JM's global headquarters has been located in downtown Denver, Colorado.

Product Description

Linacoustic® RC

Linacoustic RC is a flexible glass duct liner, manufactured using resilient glass fibers bonded with a thermosetting resin. The smooth airstream surface is protected with a durable glass-mat facing that is coated with an EPA-registered antimicrobial agent, Permacote®. This improves moisture resistance and helps protect the product against damage from mold or fungi growth. The edges of Linacoustic RC are also coated with Permacote.

Linacoustic RC duct liner has many advantages:

- **Improved Indoor Building Environment.** Linacoustic RC duct liner improves indoor environmental quality by helping to control both temperature and sound.
- **Resistant to Dust and Dirt.** The tough, acrylic polymer coating, Permacote, helps guard against the incursion of dust or dirt into the substrate, minimizing the potential for biological growth.
- **Will Not Support Microbial Growth.**[1] Permacote is formulated with an immobilized, EPA-registered anti-microbial agent in order to , to protect the coating from damage caused by potential fungi or bacterial growth.
- **Highly Resistant to Water.** Linacoustic RC's reinforced surface-coating provides superior resistance to incidental water penetration into the fiber glass wool core.
- **Cleanability.** If HVAC system cleaning is required, the airstream surface may be cleaned with industry-recognized dry methods. See the North American Insulation Manufacturers Association (NAIMA) "Cleaning Fibrous Glass Insulated Air Duct Systems." (NAIMA)

[1] Note: As with any type of surface, microbial growth may occur in accumulated duct system dirt, given certain conditions. This risk is minimized with proper design, filtration, maintenance and operation of the HVAC system.

Linacoustic® RC-HP

Linacoustic RC-HP is a flexible glass duct liner with a glass mat facing and an EPA-registerd antimicrobial top and edge coating to protect the product from damage caused by mold or mildew growth. It is designed for lining sheet metal ducts in air conditioning, heating and ventilating systems.

Linacoustic RC-HP duct liner offers the same benefits as Linacoustic RC, with two additional advantages:

- **Improved Acoustical Value.** Linacoustic RC-HP has a higher density than Linacoustic RC. This creates a higher noise reduction coefficient (NRC), improving the acoustical performance of Linacoustic RC-HP in building enviroments.
- **Improved Thermal Value.** The increased density of Linacoustic RC-HP creates a slightly improved R-value which accounts for the better thermal performance of Linacoustic RC-HP.

Duct Liner PM

Duct Liner PM is a flexible duct liner insulation made from resilient glass fibers bonded with a thermosetting resin. The airstream glass mat surface includes an EPA registered antimicrobial agent . Duct Liner PM is the most basic liner product offered by Johns Manville. Duct Liner PM meets the requirements of the NAIMA Fibrous Glass Duct Liner Standards as well as the SMACNA HVAC Duct Construction Standards.

Application and Uses

Linacoustic RC/RC-HP and Duct Liner PM are specifically designed for lining sheet metal ducts in air conditioning, heating and ventilating systems. These duct liners are engineered to provide superior acoustical performance and thermal control in applications that operate at 250°F (121°C) or below.

Manufacturing Location

This Environmental Product Declaration (EPD) represents the production of Johns Manville duct liner at Cleburne, TX.

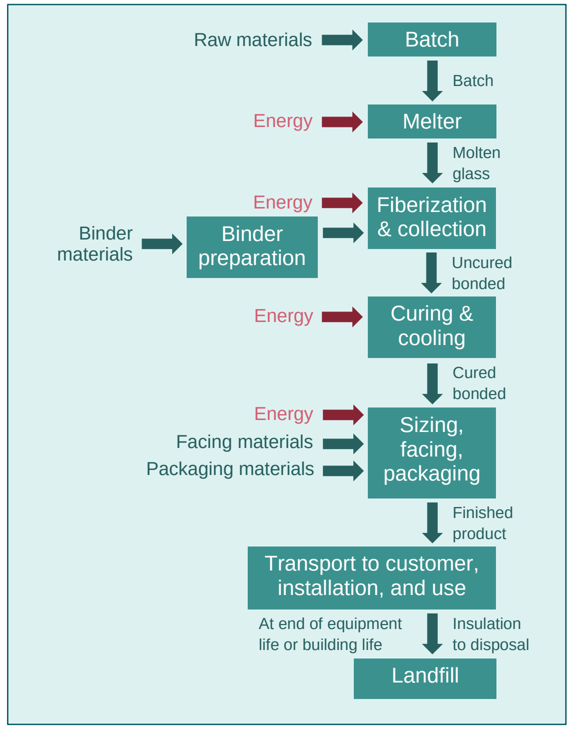
Description of Production and Subsequent Life Cycle Stages

The life cycle of the product under study begins with the extraction and processing of the raw materials that constitute the batch. Together, these materials (sand, borax, soda ash, recycled glass, and minerals) are melted. The molten glass is formed into fibers and a thermosetting binder is applied. The bonded product is then formed into insulation of the required configuration and specifications. After curing with hot air through convection and cooling, the product is cut into the desired width, faced with an acrylic latex coating (if applicable), and sent to the packaging line. Packaging of the finished product for shipment comprises shrink film and polyester bags.

Transport to the job site is an estimated 700 miles via truck. The insulation product is assumed to be tailored to customer specifications, leading to negligable material loss during installation. Only the packaging materials are sent to landfill. The use phase is considered to be burden-free for insulation products as they require no maintenance and have a 60-year reference service life equal to that of the entire building. When the building is demolished, the insulation is assumed to be sent to landfill.

Figure 1 illustrates the production and subsequent life cycle stages.

Figure 1: Production and life cycle stages



Health, Safety, and Environmental Aspects during Production

Johns Manville mechanical insulation products are designed, manufactured and tested in our own facilities, which are certified and registered to the stringent ISO 9001 (ANSI/ASQC 90) and ISO 14001 quality and environmental standards. These certifications, along with regular, independent third-party auditing for compliance, is your assurance that Johns Manville products deliver consistent high quality.

Installation

Johns Manville duct liner installation must be performed in accordance with the requirements of the NAIMA Fibrous Glass Duct Liner Standards or SMACNA HVAC Duct Construction Standard (NAIMA 2002). All transverse edges, or any edges exposed to airflow, must be coated with an approved duct liner coating material, such as Johns Manville SuperSeal products.

Linacoustic RC/RC-HP and Duct Liner PM are highly usable, resilient duct liner insulations. This facilitates efficient fabrication and installation, and reduces inventory loss during transportation and construction.

- **Minimizes Pre-installation Damage.** The durable, glass-mat facing is resistant to damage that can occur during in-shop handling, fabrication, jobsite shipping and installation.
- **Easy to Fabricate.** Linacoustic RC/RC-HP and Duct Liner PM are lightweight and easy to handle. The fiber glass is consistent throughout the core, making it easier to cut clean, even edges with regular shop tools.

Health, Safety, and Environmental Aspects during Installation

The Linacoustic® RC/RC-HP and Duct Liner PM are fiber glass duct liner products that are labeled as non-hazardous according to 29 CFR 1910.1200 when used as intended. The glass fibers are non-biopersistant (biosoluable) and are not designated as carcinogenic by the International Agency for the Research on Cancer, a branch of the World Health Organization, or the National Toxicology Program, a component of the US Department of Health and Human Service.

As with most fiber glass products, direct exposure to fibers or dust during handling may lead to mild, superficial irritation (itching) of the skin, eyes, or respiratory tract. This irritation can be avoided by using the appropriate personal protective equipment (PPE). As such, Johns Manville recommends the following PPE precautions when handling Linacoustic duct liner:

- **Respiratory**: Under typical handling and installation conditions, respiratory protection is unnecessary.
    - The North America Insulation Manufacturers Association (NAIMA) recommends the use of NIOSH N95 respirator/dust mask when occupational exposures to glass fibers exceed 1 fiber per cc (1 f/cc) for a time weighted average. Although data from the NAIMA exposure database confirm that manufacturing, fabrication, and installation activities related to this product will not result in fiber concentrations over 1 f/cc, workers may choose to use such a respirator/dust mask for comfort.
- **Hand protection**: For prolonged or repeated contact when handling Linacoustic products, discomfort or irritation can be avoided by using protective gloves.
- **Eye protection**: Safety glasses are recommended during fabrication and installation.
- **Hygiene measures**: In any industrial setting, good hygiene practices can facilitate safer and healthier working environments. We recommend practicing appropriate hygiene under any manufacturing, fabrication, or installation setting.
- **Ingestion:** Avoid ingesting or swallowing Linacoustic duct liner; however, should ingestion occur, rinse your mouth thoroughly with water to remove dust or fibers, and drink plenty of water to help reduce irritation. Should symptoms persist call a physician.

The NAIMA safety recommendations may be found at: *http://ampersand.glhserver.com/~admin13/insulation-knowledge-base/health-and-safety-aspects/product-stewardship-program-for-worker-protection.html*

Johns Manville's Linacoustic Safety Data Sheets may be located at: *https://msds.jm.com/irj/go/km/docs/documents/Public/MSDS/200000002087_US_EN.pdf*

NAIMA Fibrous Glass Duct Liner Standards or SMACNA HVAC Duct Construction Standard (NAIMA 2002) may be found at: *http://www.SMACNA.org*
NAIMA Fibrous Glass Duct Liner Standard: *http://insulationinstitute.org/wp-content/uploads/2015/11/AH124.pdf*

Life Cycle Assessment – Product System and Modeling

A "cradle-to-grave" life cycle assessment (LCA) was conducted for this EPD. The analysis was done according to the product category rule (PCR) for building envelope thermal insulation and mechanical insulation and followed LCA principles, requirements and guidelines laid out in the ISO 14040/14044 standards. As such, EPDs of construction products may not be comparable if they do not comply with the same PCR or if they are from different programs.

While the intent of the PCR is to increase comparability, there may still be differences among EPDs that comply with the same PCR (e.g., due to differences in system boundaries, background data, etc.).

Functional Unit

Per the PCR, the functional unit for this analysis is ***1 m² of insulation material with a thickness that gives an average thermal resistance R_{SI} = 1 m²K/W and with a building service life*** (RSL) ***of 60 years***. Table 1 shows the functional unit along with its specific thickness and mass reference flow.

Table 1: Functional unit and subsequent product attributes

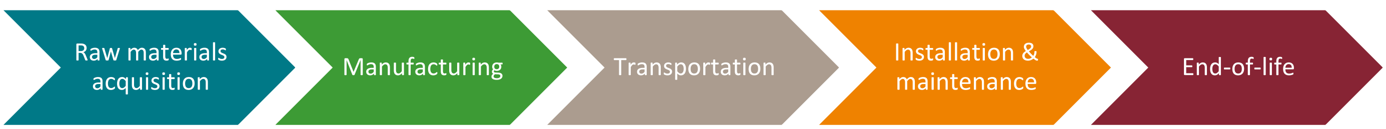
	Area [m^2]	R_{SI} [m²K/W]	R_{US} [BTU/(h °F ft^2)]	RSL [years]	Thickness [in]	Mass [kg]
Functional Unit	1	1	5.68	60	1.35	0.942

Life Cycle Stages Assessed

A cradle-to-grave life cycle assessment was conducted, from extraction of natural resources to final disposal. Within these boundaries the following stages were included:

- **Raw materials acquisition:** Raw material supply (incl. virgin and recycled materials), inbound transport
- **Manufacturing:** Production of insulation, product packaging, manufacturing waste, releases to environment
- **Transportation:** Distribution of the insulation product from the manufacturer to a distributor (if applicable) and from there, to the building site
- **Installation and Maintenance:** Installation process, installation wastes and releases to the environment, maintenance under normal conditions
- **End-of-Life:** Dismantling/demolition, transport to final disposal site, final disposition

Figure 2: Life cycle stages included in system boundary



System Boundaries

This study covers the entire life cycle of the products, including raw material acquisition and manufacturing, transportation to the building site, installation and maintenance, and finally end-of-life treatment. Additionally, transportation between stages has been accounted for, including raw material transport to the manufacturing facility and end-of-life transport to the landfill. Manufacturing facility overhead is included. Building operational energy and water use are considered outside of this study's scope: any beneficial impact that the use of insulation may have on a building's energy consumption is not calculated or incorporated into the analysis.

Assumptions

The analysis uses the following assumptions:

- Insulation is assumed to have a 60-year reference service life, equal to that of the building.
- Installation is done by hand and assumed to have a negligible scrap rate (0%).

Cut-off Criteria

Processes or activities that contribute no more than 2% of the total mass and 1% of the total energy may be omitted under PCR cut-off criteria. If omitted material flows have relevant contributions to the selected impact categories, their exclusion must be justified by a sensitivity analysis.

Cut-off criteria were applied to capital equipment production and maintenance under the assumption that the impacts associated with these aspects were sufficiently small enough to fall below cut-off when scaled down to the functional unit. All energy and material flow data available were included in the model.

Transportation

Reported transportation distances via truck and rail are included for the inbound transport of raw materials to the production facility. Distribution of the finished product to the cosntruction site is estimated at 700 miles via heavy-duty truck and assumed to be volume-limited rather than mass-limited, with a utilization rate of 28% of mass capacity.

Period under Consideration

Primary data were collected on insulation production in 2014.

Background Data

The LCA model was created using the GaBi ts software system for life cycle engineering, developed by thinkstep. The GaBi 2015 LCI database provided the life cycle inventory data for upstream and downstream processes of the background system. US-specific background data were used whenever possible, with European or global data substituted as proxies as necessary.

Data Quality

Data quality and representativeness are considered to be good to high. Foreground data were collected from Johns Manville's manufacturing facility, with seasonal variations accounted for by collecting 12 months-worth of data. Aside from capital equipment, no data were omitted under cut-off criteria. All primary data were collected with the same level of detail while all background data were sourced from the GaBi databases. Allocation and other methodological choices were made consistently throughout the model.

Allocation

Data collection was performed by Johns Manville reaching out directly to plant facility managers. Specific data were collected for raw material use; however, energy use posed a considerable challenge to attribute to the products. The only exception was natural gas, where process-level boiler and furnace energy use was available. For electricity and other facility fuel use, only site-level and multi-process data were available. These data were normalized by the mass of product manufactured at the facility over the temporal scope. Air emissions were also unavailable at the process-level; therefore, a facility air emission report was leveraged to attribute the emissions to per declared unit of product

Use

Duct insulation is assumed to have a reference service life of 60 years, equal to that of the building. Once installed, insulation does not directly consume energy, but instead, contributes to a reduction in the amount of energy required to ehat and cool the building. The insulation requires no maintenance, and there are no parts to repair or refurbish. Any reduction in building operational energy consumption associated with insulation use needs to be considered on the level of the individual building and is considered outside the scope of this LCA.

End-of-Life

At end-of-life, insulation is removed from the deconstructed building. Wastes are then disposed in a landfill. While insulation can theoretically be reused or recycled, doing so is not common practice in the industry. Therefore, the analysis assumes that after removal, the insulation is transported to the disposal site and landfilled.

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Life Cycle Assessment – Results and Analysis

Use of Material and Energy Resources

Table 2 and Table 3 show the material resource use and primary energy demands per functional unit, respectively. Energy resource consumption is broken down by type and by resource. Figures 3 and 4 illustrate the results graphically.

Table 2: Material resource use per functional unit

Material Resources	Unit	Value
Non-renewable material resources	kg	6.09
Renewable material resources	kg	25
Net water use	L (kg)	17.5

Table 3: Primary energy demand per functional unit

Primary Energy Demand	Unit	Value
Non-renewable	***MJ***	***79.7***
Crude oil	MJ	12.7
Hard coal	MJ	5.48
Lignite	MJ	1.87
Natural gas	MJ	57.9
Uranium	MJ	1.74
Renewable	***MJ***	***1.5***
Biomass	MJ	2.95E-11
Geothermal	MJ	0.00956
Hydro power	MJ	0.138
Solar power	MJ	0.6
Wind power	MJ	0.725
Total	***MJ***	***81.2***

Figure 3: Non-renewable primary energy resources

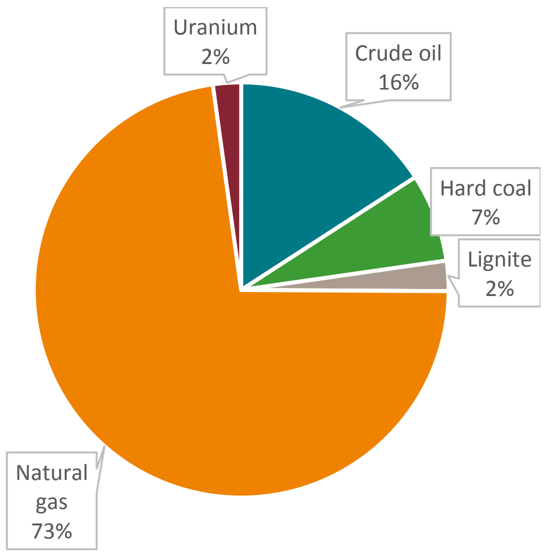
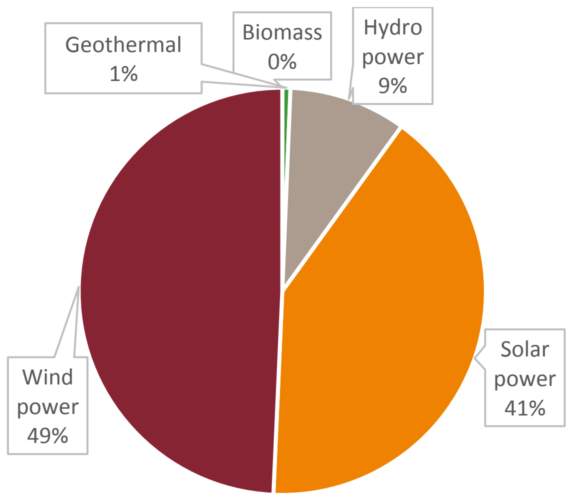


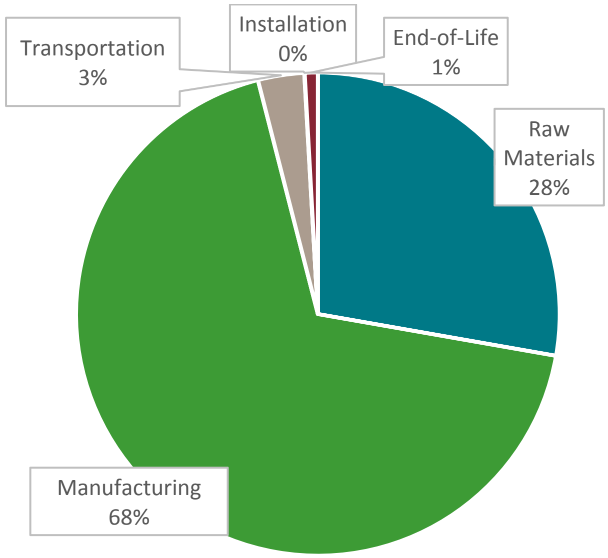
Figure 4: Renewable primary energy resources



Primary Energy by Life Cycle Stage

Primary energy demand contribution over the life cycle of the product is shown in Figure 5. Manufacturing is the dominant contributor overall; however, raw material supply is significant as well. In the manufacturing stage, electricity consumption, natural gas and other fossil fuel combustion are considered. Raw materials require energy in their extraction and refining. Moreover, materials such as plastic and biomass can be used as energy resources and the value of this energy is included in the primary energy demand indicator.

Figure 5: Primary energy demand breakdown by life cycle stage



Waste to Disposal

Wastes generated from cradle-to-grave are shown in Table 4. There is a significant mass of non-hazardous waste at end-of-life which represents the product itself when the insulation is decommissioned and discarded to landfill.

Table 4: Waste to disposal/energy per functional unit

Impact Category	Units	TOTAL	Raw Materials	Manufac-turing	Transporta-tion	Installation	End-of-Life
Hazardous (kg)	kg	**1.73E-05**	3.56E-06	1.32E-05	3.55E-07	2.96E-09	1.30E-07
Non-hazardous (kg)	kg	**1.22**	0.04	0.22	0.00	0.02	0.94
Waste to energy	kg	**0**	0	0	0	0	0

Life Cycle Impact Assessment

Table 5 contains life cycle impact assessment results per functional unit. Impact results were calculated using the TRACI 2.1 methodology. Note: Since the publishing of the guiding PCR, the unit for Acification in TRACI has changed from *kg mol* H^+ *eq* (TRACI 2.0) to *kg* SO_2 *eq* (TRACI 2.1).

Table 5: Life cycle impact category results per functional unit (TRACI 2.1)

Impact Category	Units	TOTAL	Raw Materials	Manufac-turing	Transporta-tion	Installation	End-of-Life
Acidification	kg SO_2 eq	**0.0367**	0.00465	0.0309	0.000907	0.0000151	0.0002
Eutrophication	kg N eq	**0.00266**	0.000643	0.00192	0.0000808	0.00000573	0.0000109
Global Warming*	kg CO_2 eq	**4.85**	1.24	3.39	0.175	0.000971	0.0426
Ozone Depletion	kg CFC-11 eq	**1.65E-10**	3.41E-11	1.28E-10	1.5E-12	2.33E-14	1.02E-12
Smog Creation	kg O_3 eq	**0.305**	0.0765	0.196	0.0288	0.000127	0.00389

* Excl. biogenic carbon

Interpretation

Manufacturing drives all TRACI impact categories. Electricity generation and natural gas combustion dominate global warming and ozone depletion, respectively. For acidification, eutrophication and smog formation potentials, the reported NO_x facility air emissions are the dominant contributor. There is significant contribution to all impact categories from upstream production of raw materials, largely attributed to acrylic latex coating, soda ash, phenol formaldehyde, burnt dolomite, and borax; however, the relative contributions vary depending on the impact category. There are unique exceptions, such as soybean-oil derived dedusting oil contributing to eutrophication and tailpipe emissions from transportation contributing to smog formation potential.

Transportation to the installation site represents a minor driver of impacts. Installation accounts for a negligable impact fraction given that minimal resources are required to install the mechanical insulation. There is no impact associated with the use stage. While insulation can influence building energy performance, this aspect is outside the scope of this study. Additionally, it is assumed that insulation does not require any maintenance to achieve its reference service life, which is modeled as being equal to that of the building (i.e., 60 years). No replacements are necessary. At end-of-life (EoL), insulation is removed from the building and landfilled. Non-hazardous waste was dominated by the EoL disposal of the entire functional unit of product. Non-hazardous waste also accounts for waste generated during manufacturing and installation. Hazardous waste is driven by waste from raw material production and manufacturing; however, the amount of hazardous waste generated is a small fraction of the total waste produced.

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