LIFE CYCLE ASSESSMENT (LCA) OF INTERNATIONAL CELLULOSE CORPORATION INSULATION PRODUCTS

Status	Final
Client	International Cellulose Corporation (ICC)
Date	October 2020
Author(s)	Manuela Toro

Contents

1 INTRODUCTION

1.1 Opportunity

International Cellulose Corporation (ICC) is the world's leading developer and manufacturer of cellulose spray-applied thermal insulation and acoustical finishes. In fulfilling their commitment to sustainability, it is important that ICC conduct Life Cycle Assessments to evaluate the environmental impacts of their products in all life cycle stages, from raw materials to manufacturing and through to the end of life. The goal of creating a Life Cycle Assessment is to discover the full range of environmental impacts the products have and to identify ways to improve processes and reduce impacts throughout the life cycle of the products. This project is important to ICC's commitment to provide the market with the information it needs to be able to assess the environmental impacts of their products.

To understand the complete impact of this product through all life cycle stages, ICC has decided to use a cradle-to-grave approach in conducting the Life Cycle Assessment. By taking all stages into account a more comprehensive study of the product is created.

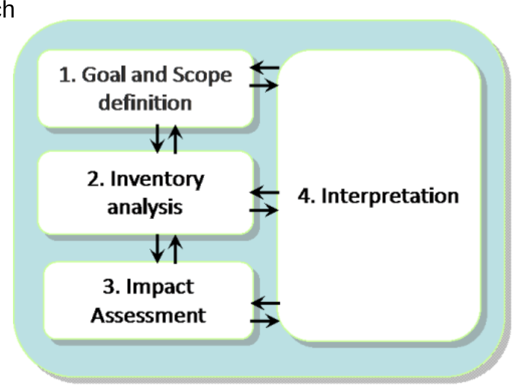
ICC is interested in having Life Cycle Assessment (LCA) data available for its products to be able to obtain a Sustainable Minds Transparency Report™, a Type III Environmental Declaration that can be used for communication with and amongst other companies, architects, and consumer communication, and that can also be utilized in whole building LCA tools in conjunction with the LCA background report and LCI.

ICC commissioned Sustainable Minds to develop LCAs for their insulation products. ICC wants to learn from the results and is looking forward to having guidance for future product improvements that can be deduced from the results.

1.2 Life Cycle Assessment

This life cycle assessment (LCA) follows the UL Environment (ULE) PCR for Building Envelope Thermal Insulation v2.0, which was updated and republished under the Part A and Part B format to conform to EN 15804 and ISO 21930:2017 [1]. This report includes the following phases:

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



Source: ISO 14040

An ISO 14040-44 third-party review and a third-party report verification for Transparency Reports are required in order to use Transparency Reports as Type III Environmental Declarations. The third-party review and third-party Transparency Report verification will both be completed in this project.

1.3 Status

All information in this report reflects the best possible inventory by ICC at the time it was collected, and best practices were conducted by Sustainable Minds and ICC employees to transform this information into this LCA report. The data covers annual manufacturing data for 1/2018-12/2018 from ICC's manufacturing location in Houston, TX. Where data was missing, assumptions were made from manufacturing data for this facility based upon expertise from ICC employees.

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

ICC has chosen to have the LCA report undergo third-party review and the Transparency Reports undergo third-party verification. This review and verification will be performed by NSF to assess conformance to ISO 14040/14044 and the ULE PCRs.

1.4 Team

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

- Lauren Kempe, Architectural Sales Representative

Lauren has been assisted by numerous ICC employees during the data collection, reporting, and interpretation phases.

From Sustainable Minds:

- Kelli Young, LCA Practitioner
- Kim Lewis, LCA Internal Reviewer

1.5 Structure

This report follows the following structure:

- Chapter 2: Goal and scope
- Chapter 3: Inventory analysis
- Chapter 4: Impact assessment
- Chapter 5: Interpretation
- Chapter 6: Sources

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.

2 GOAL AND SCOPE

This chapter explains the starting points for the LCA. The aim of the goal and scope is to define the products under study and the depth and width of the analysis.

2.1 Intended application and audience

This report intends to define the specific application of the LCA methodology to the life cycle of ICC products. It is intended for both internal and external purposes. The intended audience includes the program operator (Sustainable Minds) and reviewers who will be assessing the LCA for conformance to the PCRs, as well as ICC internal stakeholders involved in marketing and communications, operations, and design. Results presented in this document are not intended to support comparative assertions within this study. However, the results will be disclosed to the public in Sustainable Minds Transparency Reports (Type III Environmental Declarations per ISO 14025) which are focused on products that are available in the US market. These Transparency Reports will undergo critical review for conformance to the PCRs.

2.2 Insulation products

As the world's leading developer and manufacturer of cellulose spray-applied thermal insulation and acoustical finishes, ICC represents one of the most respected names in insulation worldwide. As a manufacturer of cellulose insulation products, ICC is interested in demonstrating its sustainability leadership and leveraging business value associated with transparent reporting of its products' cradle-to-grave environmental impacts. For more information on ICC insulation products, go to http://www.spray-on.com/.

The products studied in this report and their manufacturing location are listed in Table 2.2a. The declaration names with products represented and type of declaration, and other product information for each product are listed in Tables 2.2b and 2.2c, respectively.

Table 2.2a Product names and manufacturing location

Product name	Manufacturing location
K-13 & ThermoCon	Houston, TX
Ure-K	Houston, TX
SonaSpray "fc" & ThermoCon FC	Houston, TX
SonaKrete & ThermoCon TR	Houston, TX

Table 2.2b Declaration names with products represented and type of declaration

Transparency Report name	Product name	Type of declaration
K-13 & ThermoCon	K-13 & ThermoCon	One specific product from the manufacturer's plant.
Ure-K	Ure-K	One specific product from the manufacturer's plant.
SonaSpray "fc" & ThermoCon FC	SonaSpray "fc" & ThermoCon FC	One specific product from the manufacturer's plant.

SonaKrete & ThermoCon TR	SonaKrete & ThermoCon TR	One specific product from the manufacturer's plant.

Table 2.2c Other product information

Transparency Report name	CSI MasterFormat® classification	Application	ASTM or ANSI product specification
K-13 & ThermoCon	09 83 16 07 21 29	K-13 is a total system of recycled natural fibers, chemical treatment, binding system and application method. The K-13 system begins with specially prepared cellulose fibers which are chemically treated. K-13 is produced in a strict, quality controlled manufacturing process. K-13 is applied by an international network of licensed applicators through approved fiber machines and nozzles for control of the fiber/binder ratio. During application, the K-13 fibers are combined with a patented adhesive. The finished product is a strong, durable monolithic coating of a predetermined thickness. Some surfaces will require priming prior to being sprayed.	• ASTM-C-518 Thermal Conductivity • ASTM E-119 Full Scale Fire Wall Test, including Hose Stream Test • ASTM E-84 Surface Burning Characteristics • ASTM C-423 Noise Reduction Coefficients • ASTM C-523 Light Reflectance • ASTM E-736 Bond Strength • ASTM E-859 Air Erosion • ASTM C-739 Moisture Absorption • ASTM E-90 Sound Transmission Loss • ASTM E-413 Sound Transmission Loss • ASTM E-1042 Acoustical Absorption • ASTM C-1149 Spray-applied Cellulose Insulation (http://www.spray-on.com/products/k13/)
Ure-K	09 83 16 07 21 29	Ure-K may be sprayed over foam in existing buildings or it can be used as a protective coating over foam in new construction projects as a combination system. It is applied with a ranger machine.	•ASTM C 518 •ASTM E 736 •ASTM E 84/ UL 723 •ASTM E 119 •ASTM E 1042 (http://www.spray-on.com/wp-content/pdfs/specs/UREK_SPEC.pdf)
SonaSpray "fc" & ThermoCon FC	09 83 16	SonaSpray "fc" is a spray applied acoustical texture designed for a wide range of project types. SonaSpray "fc" provides an attractive, high performance solution to acoustical and lighting design objectives in both new construction and renovation projects. Typical installations include: schools, churches, passenger terminals, libraries, cafeterias, offices, hotels and condominiums. It is applied with a ranger machine.	•ASTM E-84/UL 723 •ASTM E-736 •ASTM E-761 (http://www.spray-on.com/wp-content/pdfs/specs/SONASPRAY_SPEC.pdf)
SonaKrete & ThermoCon TR	09 83 16	SonaKrete was developed to satisfy the need for a refined, aesthetically pleasing finish that would be appropriate for both historical restoration and modern design trends. High-quality installations are assured because ICC has licensed only those contractors who have reputations for outstanding workman-ship with our other spray acoustic and thermal insulation systems. That, in combination with our field technical support, results in installations that get favorable reviews from everyone associated with each project. It is applied with a ranger machine.	• ASTM E 84: Surface Burning Characteristics: Class 1 Class A Rated • Smoke Development: 5 Flame Spread: 10 • ASTM E 736: Bond Strength: > 800 PSF • ASTM C 1338-14: Fungal Resistance: No Growth/ Pass • UL 2821: GREENGUARD Method for Evaluating Chemical Emissions from Building Materials, Finishes and Furnishings. • GREENGUARD Gold Certified per UL® Environmental • ASTM D 2244: Light Reflectance Value (LRV): Arctic White = 91 White = 89 (http://www.spray-on.com/wp-content/pdfs/specs/SONAKRETE_SPEC.pdf)

2.3 Functional unit

The results of the LCA in this report are expressed in terms of a functional unit, as it covers the entire life cycle of the products. Per the PCR [1], the functional unit is:

> 1 m^2 of installed insulation material with a thickness that gives an average thermal resistance R_{SI} = 1 m^2·K/W and with a building service life of 75 years (packaging included)

Building envelope thermal insulation is assumed to have a reference service life equal to that of the building, which in this case is 75 years [1]. The insulation does not need to be replaced, and 1 m^2 of insulation plus packaging is required to fulfill the functional unit. This reference service life applies for the reference in-use conditions only.

Reference flows express the mass of product required to fulfill the functional or declared unit and are calculated based on the nominal insulation density for the R-value closest to R_{SI} = 1 m^2·K/W, which varies for each product. Reference flows are listed in Table 2.3a.

Table 2.3a Reference flows

Product	**Insulation (kg)**	**Packaging (kg)**	**Thickness at RSI=1 (m)**	**Reference flow total (kg)**
K-13 & ThermoCon	0.0082	0.0002	0.0384	2.1502
Ure-K	0.0087	0.0002	0.0318	2.289
E SonaSpray "fc" & ThermoCon FC	0.007	0.0001	0.0483	4.252
SonaKrete & ThermoCon TR	0.0062	0.0001	0.0483	4.252

2.4 System boundaries

This section describes the system boundaries for the products.

The system boundaries define which life cycle stages are included and which are excluded. any impact the use of insulation may have on a building's energy consumption is not calculated nor incorporated into this analysis.

This LCA's system boundaries include the following life cycle stages:

I. A1-A5
- Raw materials acquisition, transportation, and manufacturing
- Distribution and installation

II. B1-B7
- Use

III. C1-C4
- Disposal/reuse/recycling

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 the PCRs [1].

The system boundaries for ICC products are detailed below. Figure 2.4a represents the life cycle stages for the entire life cycle of these products. Table 2.4a lists specific inclusions and exclusions for the system boundaries.

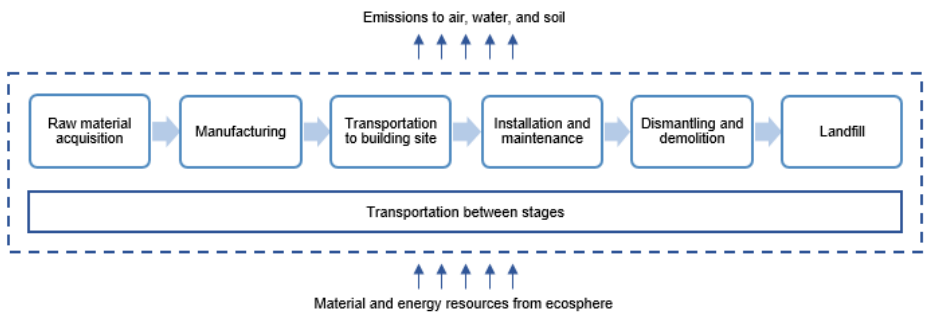


Figure 2.4a Applied system boundaries for the modeled insulation products

Table 2.4a System boundaries

Included	Excluded
• Raw material acquisition and processing • Processing of materials • Energy production • Transport of raw materials • Outbound transportation of products • Overhead energy (heating, lighting, forming, finishing, etc.) of manufacturing facilities • Packaging of final products • Installation and maintenance, including material loss, energy use, and auxiliary material requirements • End-of-life, including transportation	• Construction of major capital equipment • Maintenance and operation of support equipment • Human labor and employee transport • Manufacture and transport of packaging materials not associated with final product • Disposal of packaging materials not associated with final product • Building operational energy and water use

2.4.1. A1-A3: Raw materials acquisition, transportation, and manufacturing

Raw materials acquisition and transportation (A1-A2)

The RM acquisition and transportation stage includes, where relevant, the following processes:

- Extraction and processing of raw materials
- Average transport of raw materials from extraction/production to manufacturer
- Processing of recycled materials
- Transport of recycled/used materials to manufacturer

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

Manufacturing (A3)

The manufacturing stage includes the following:

- Manufacturing of building envelope thermal insulation products
- Packaging
- Releases to environmental media (air, soil, ground and surface water)
- Manufacturing waste

2.4.2. A4-A5: Distribution and installation

Distribution (A4)
The transportation stage includes the following:
- Transportation of building envelope thermal insulation products from manufacturer to distributor/building site
- Transport of building envelope thermal insulation products from distributor to building site, if applicable

Installation (A5)
The installation stage includes the following:
- Installation on the building including any materials specifically required for installation
- Construction waste
- The reference service life of the building is defined as 75 years for building envelope thermal insulation, and the number of replacements of the insulation products will be declared accordingly. The number of replacements shall be calculated by dividing the reference service life of the building by the product service life as defined by the manufacturer's specifications.
- Releases to environmental media (air, soil, ground and surface water) of the product during installation and life of the product will be declared in accordance with current U.S. national standards and practice.
- Installation waste

2.4.3. B1-B7: Use

The use stage includes:
- Product use
- Maintenance
- Repair
- Replacement
- Refurbishment
- Operational energy use
- Operational water use

2.4.4. C1-C4: Disposal/reuse/recycling

Deconstruction (C1)
The deconstruction stage includes dismantling/demolition.

Transport (C2)
The transport stage includes transport from building site to final disposition.

Waste processing (C3)
The waste processing stage includes processing required before final disposition.

Disposal (C4)
The disposal stage includes final disposition (e.g. recycling/reuse/landfill/waste incineration/conversion to energy).

3 INVENTORY ANALYSIS

This chapter includes an overview of the obtained data and data quality that has been used in this study. For the complete life cycle inventory which catalogues the flows crossing the system boundary and provides the starting point for life cycle impact assessment, see the attached spreadsheets [2].

3.1 Data collection

Data used for this project represents a mix of primary data collected from ICC [3] on the production of the insulation products (gate-to-gate) and background data from SimaPro databases. Overall, the quality of the data used in this study is considered to be high and representative of the described systems. All appropriate means were employed to guarantee the data quality and representativeness as described below.

- **Gate-to-gate:** Data on processing materials and manufacturing the insulation products were collected in a consistent manner and level of detail to ensure high quality data. All submitted data were checked for quality multiple times on the plausibility of inputs and outputs. All questions regarding data were resolved with ICC. Data were collected at ICC's Houston, TX facility.

- **Background data:** All data from SimaPro were created with consistent system boundaries and upstream data. Expert judgment and advice was used in selecting appropriate datasets to model the materials and energy for this study and has been noted in the preceding sections. Detailed database documentation for EcoInvent can be accessed at: https://www.ecoinvent.org/database/database.html.

All primary data were provided by ICC. Upon receipt, data were cross-checked for completeness and plausibility using mass balance, stoichiometry, and benchmarking. If gaps, outliers, or other inconsistencies occurred, Sustainable Minds engaged with ICC to resolve any open issues.

3.2 Primary data

The spray-applied thermal/acoustical finish systems are produced in several manufacturing steps that involve manufacturing the fibers as well as the adhesive. The manufacturing steps that involve manufacturing the fibers include inspection/sorting, shredding, fiberization, and bagging. The manufacturing steps that involve the manufacturing of the adhesive include adhesive production and adhesive storage.

The finished products are then distributed to construction sites where the adhesive and fiber is installed, and the packaging is disposed (sent to landfill). Building envelope thermal insulation has a 75-year reference service life which is equal to that of the building. At end of life, the insulation is removed and disposed in a landfill. The flow charts in Figure 3.2a illustrate the life cycle of the insulation products.

Data used in this analysis represent insulation production at ICC. Results were then scaled to reflect the functional unit.

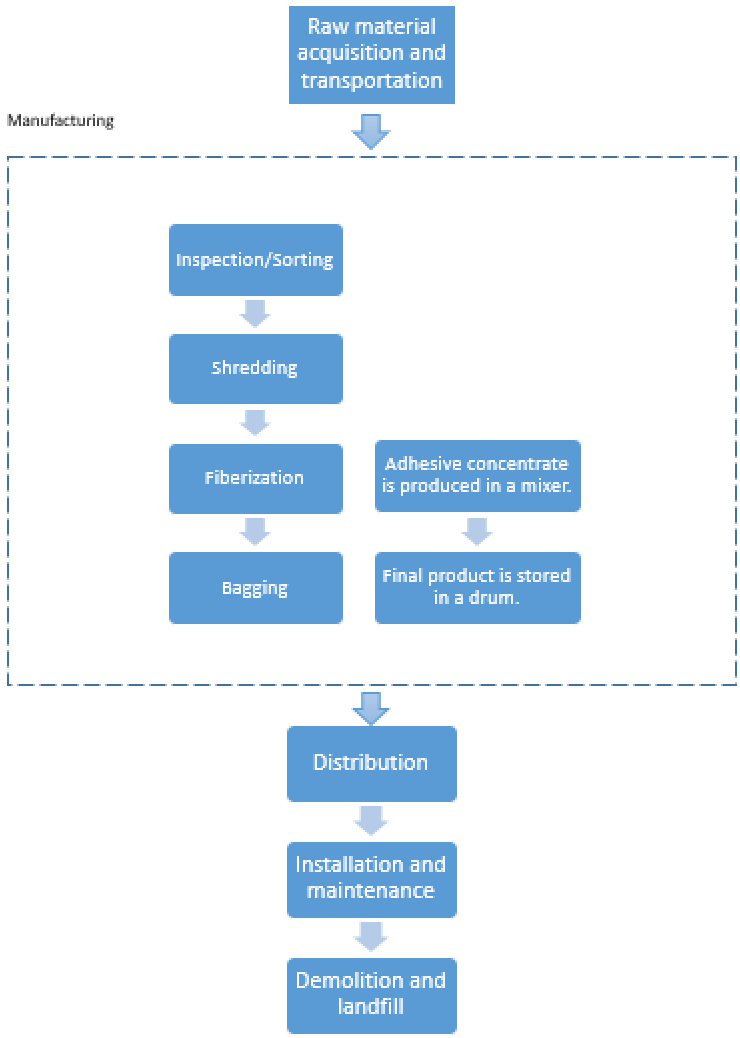


Figure 3.2a Life cycle flow chart of insulation products production

3.2.1. Raw Materials acquisition and transportation (A1-A2)

Raw materials acquisition and transportation represents the first stage of the insulation products' life cycle. Mixed recycled paper, boric acid, sodium borate and other raw materials are transported to ICC's facility. Raw material inputs for the products are listed in Tables 3.2a-d. Since mixed papers and waste papers are secondary materials, they are assumed to arrive at the facilities burden-free aside from the transportation necessary to deliver them.

The product does not contain substances that are identified as hazardous according to standards or regulations of the Resource Conservation and Recovery Act (RCRA), Subtitle C, nor does it (or its associated processes) release dangerous, regulated substances that affect health and environment, including indoor air emissions, gamma or ionizing radiation emissions, or chemicals released to the air or leached to water and soil [4].

It should be noted that while packaging materials are listed as raw material inputs, their impacts lie within the manufacturing stage for this study. Since the functional unit includes packaging, it is simpler to compare the reference flow to the percentage of each input.

Raw materials are transported to ICC's facilities via both ship and truck. Transport data were collected for each flow and are shown in Tables 3.2a-d for transportation to Houston, TX.

Table 3.2a K-13 & Thermocon raw material inputs

Flow	Mass percentage	Transportation mode	Distance (mi)
Mixed recycled papers	54.12%	Truck and trailer	813
Boric acid	11.03%	Truck and trailer	15
Sodium borate	1.83%	Truck and trailer	15
Mineral oil/distillates	0.68%	Forklift	0.2
Water	23.66%	N/A	N/A
PVA	5.22%	Truck and trailer	25
Part B	1.84%	Tanker truck	1060
Plastic bags (packaging)	0.06%	Box Truck	42
Plastic drums (packaging)	1.55%	Truck and trailer	17.4
PE film (packaging)	0.03%	Truck and trailer	28
Raw material packaging			
Waste paper wires	0.02%	Truck and trailer	813
Cardboard box	0.001%	Box Truck	42

Table 3.2b Ure-K raw material inputs

Flow	Mass percentage	Transportation mode	Distance (mi)
Mixed recycled papers	54.17%	Truck and trailer	813
Boric acid	11.04%	Truck and trailer	15
Sodium borate	1.83%	Truck and trailer	15
Mineral oil/distillates	0.68%	Forklift	0.2
Water	23.66%	N/A	N/A
PVA	5.22%	Truck and trailer	25
Part B	1.84%	Tanker truck	1060
Plastic bags (packaging)	0.06%	Box Truck	42
Plastic drums (packaging)	1.46%	Truck and trailer	17.4
PE film (packaging)	0.03%	Truck and trailer	28
Raw material packaging			
Waste paper wires	0.02%	Truck and trailer	813
Cardboard box	0.002%	Box Truck	42

Table 3.2c SonaSpray "fc" & ThermoCon FC raw material inputs

Flow	Mass percentage	Transportation mode	Distance (mi)
Mixed recycled papers	53.99%	Ship; Truck and trailer	6070.40
Boric acid	11.00%	Truck and trailer	15
Sodium borate	1.82%	Truck and trailer	15
Mineral oil/distillates	0.67%	Forklift	0.2
Ferric Oxide	0.0004%	Truck and trailer	20
Water	20.99%	N/A	N/A
PVA	4.94%	Truck and trailer	25
Part B	4.94%	Tanker truck	1060
Plastic bags (packaging)	0.06%	Box Truck	42
Plastic drums (packaging)	1.55%	Truck and trailer	17.4
PE film (packaging)	0.03%	Truck and trailer	28

Raw material packaging			
Waste paper wires	0.02%	Ship; Truck and trailer	6070.40
Cardboard box	0.002%	Box Truck	42

Table 3.2d SonaKrete & ThermoCon TR raw material inputs

Flow	Mass percentage	Transportation mode	Distance (mi)
Mixed recycled papers	54.16%	Ship; Truck and trailer	6070.40
Boric acid	11.03%	Truck and trailer	15
Sodium borate	1.83%	Truck and trailer	15
Mineral oil/distillates	0.68%	Forklift	0.2
Water	23.61%	N/A	N/A
PVA	5.21%	Truck and trailer	25
Part B	1.84%	Tanker truck	1060
Plastic bags (packaging)	0.05%	Box Truck	42
Plastic drums (packaging)	1.55%	Truck and trailer	17.4
PE film (packaging)	0.03%	Truck and trailer	28
Raw material packaging			
Waste paper wires	0.01%	Ship; Truck and trailer	6070.40
Cardboard box	0.01%	Box Truck	42

3.2.2. Manufacturing (A3)

After the raw materials are transported to ICC's facility, the mixed recycled paper is inspected and sorted for quality control. The fibers that do not meet the standards are removed. Then the paper is conveyed under a magnet to ensure the removal of any metal. The paper is then shredded. After the paper is shredded, it is fiberized and combined with fire retardants and other additives. Meanwhile, adhesive concentrate is produced in an industrial mixer and the final product is stored in a drum.

Annual manufacturing inputs and outputs for the remaining products are shown in Tables 3.2.2a-d. Emissions associated with the production of electricity and the combustion of natural gas are accounted for in the EcoInvent background processes.

Table 3.2.2a K-13 & Thermocon annual manufacturing inputs and outputs

	Flow	Amount	Unit
Inputs	Electricity	846684.39	kWh
	Natural gas	7,408.60	MJ
Outputs	Packaged product	6,854,689.86	kg
	Waste paper wires	1,542	kg
	Cardboard box	100	kg

Table 3.2.2b Ure-K annual manufacturing inputs and outputs

	Flow	Amount	Unit
Inputs	Electricity	49862.48	kWh
	Natural gas	437.85	MJ
Outputs	Packaged product	403,697.33	kg
	Waste paper wires	91	kg
	Cardboard box	8	kg

Table 3.2.2c SonaSpray "fc" & ThermoCon FC annual manufacturing inputs and outputs

	Flow	Amount	Unit

Inputs	Electricity	130685.31	kWh
	Natural gas	1,243.91	MJ
Outputs	Packaged product	1,153,032.14	kg
	Waste paper wires	263	kg
	Cardboard box	18	kg

Table 3.2.2d SonaKrete & ThermoCon TR annual manufacturing inputs and outputs

	Flow	Amount	Unit
Inputs	Electricity	8473.36	kWh
	Natural gas	73.85	MJ
Outputs	Packaged product	68,492.47	kg
	Waste paper wires	9	kg
	Cardboard box	4	kg

3.2.3. Distribution (A4)

Products are packaged in the manufacturing plant and shipped directly to distributers, dealers, and showrooms for purchase by the end users in the US. A transportation distance of 1,000 miles is assumed based on information provided by ICC [3]. Based on ICC's records, all products are shipped by truck. Table 3.2.3 details insulation distribution.

Table 3.2.3 Distribution for insulation products

Product	Value	Unit
Truck transport		
K-13 & ThermoCon	1,000	mi
Ure-K	1,000	mi
SonaSpray & ThermoCon FC	1,000	mi
SonaKrete & ThermoCon TR	1,000	mi

i

3.2.4. Installation (A5)

At the installation site, an insulation blower is used to spray on the fiber and adhesive. This is the first time the fiber and adhesive are mixed. Adhesive concentrate is diluted with water onsite. The electricity used by the insulation blower as well as the water used to dilute the adhesive are taken into account.

The plastic packaging of the fiber is sent to landfill and the plastic drums used for the adhesive concentrate are recycled. Based on data given by manufacturers, the amount of electricity used in installation by blowers and the amount of water used to dilute the adhesive annually was modeled and is shown in Table 3.2.4a.

Table 3.2.4a Gas and water used one annual production for installation

Product	Electricity (kWh)	Water (kg)
K-13 & ThermoCon	1,233,844	8,205,350
Ure-K	72,666	483,225
SonaSpray & ThermoCon FC	207,546	1,377,032
SonaKrete & ThermoCon TR	12,329	82,118

Plastic fiber packaging is assumed to be thrown away into landfill after installation. 100% of the fiber packaging is assumed to be landfilled for each product. The drums used as packaging for the adhesive concentrate are recycled. A dummy process was created for the recycled material.

3.2.5. Use (B1-B7)

Insulation's reference service life is assumed to be equal to that of the building, which is 75 years for building envelope thermal insulation. No maintenance or replacement is required to achieve this product life span. Because the installed product is expected to remain undisturbed during the life of the building, there are assumed to be no impacts associated with the use stage.

3.2.6. Deconstruction (C1)

Removal at end of life requires human labor only and therefore does not contribute to the lifetime environmental impacts.

3.2.7. Transport (C2)

After removal, the insulation is assumed to be transported 100 miles to the disposal site to be landfilled.

3.2.8. Waste processing (C3)

No waste processing is required before being landfilled.

3.2.9. Disposal (C4)

After removal, the insulation is assumed to be landfilled. Since removal is typically associated with demolition or remodeling activities, the insulation is not assumed to be reused or recycled. Any biogenic carbon that is part of any binder is assumed to be sequestered in the landfill.

3.3 Data selection and quality

The data used to create the inventory model shall be as precise, complete, consistent, and representative as possible with regards to the goal and scope of the study under given time and budget constraints.

- Measured primary data is considered to be of the highest precision, followed by calculated and estimated data.
- Completeness is judged based on the completeness of the inputs and outputs per unit process and the completeness of the unit processes themselves. Wherever data were available on material and energy flows, these were included in the model.
- Consistency refers to modeling choices and data sources. The goal is to ensure that differences in results occur due to actual differences between product systems, and not due to inconsistencies in modeling choices, data sources, emission factors, or other.

- Representativeness expresses the degree to which the data matches the geographical, temporal, and technological requirements defined in the study's goal and scope.

An evaluation of the data quality with regard to these requirements is provided in the interpretation chapter of this report.

Time coverage. Primary data were collected on insulation production for January 2018 to December 2018. These dates were chosen in order to capture a representative picture of ICC's products. Background data for upstream and downstream processes (i.e. raw materials, energy resources, transportation, and ancillary materials) were obtained from the EcoInvent databases.

Technology coverage. Data were collected for spray-on insulation production at ICC's facility in the US.

Geographical coverage. ICC's facility is located in Houston, TX. As such, the geographical coverage for this study is based on United States system boundaries for all processes and products. Whenever US background data were not readily available, European data or global data were used as proxies. Following production, insulation is shipped for use within the continental United States. Use and end-of-life impact were modeled using background data that represents average conditions for this region.

3.4 Background data

This section details background datasets used in modeling insulation product environmental performance. Each table lists dataset purpose, name, source, reference year, and location.

3.4.1. Fuels and energy

National and regional averages for fuel inputs and electricity grid mixes were obtained from SimaPro. The grid mixes used for electricity are from the North American Regional Reliability Councils and Interconnections (NERC). For Houston, TX, the TRE electric grid is used. Table 3.4.1 shows the most relevant LCI datasets used in modeling the product systems.

Table 3.4.1 Key energy datasets used in inventory analysis

Energy	Dataset name	Primary source	Reference year	Geography
Electricity	Electricity grid mix – TRE	NERC	2014	US TRE
Technical heat	Heat, natural gas	EI v3	2014	Global

3.4.2. Raw materials production

Data for up- and down-stream raw materials were obtained from the EcoInvent database. Table 3.4.3 shows the most relevant LCI datasets used in modeling the raw materials.

Table 3.4.2 Key material datasets used in inventory analysis

Raw material	Dataset name	Primary source	Reference year	Geography
Product	Boric acid	EI v3	2014	Global
Product	White mineral oil	E I2.2	2008	US
Product	Chemical, organic	EI v3	2014	Global
Product	Water, ultrapure	EI v3	2014	Global
Product	Sodium borate	EI v3	2014	Global
Product	Ethylene vinyl acetate	EI v3	2014	Global
Packaging	Packaaging film	EI v3	2014	Global
Packaging	Polycarbonate	EI v3	2014	Global
Packaging	Steel, low-alloyed	EI v3	2014	Global
Packaging	Corrugated board box	EI v3	2014	Global

3.4.3. Transportation

Average transportation distances and modes of transport are included for the transport of the raw materials to production facilities. Typical vehicles used include trailers and boats.

Table 3.4.4 Key transportation datasets used in inventory analysis

Transportation	Dataset name	Primary source	Reference year	Geography
Truck and trailer 53'	Transport, lorry, 16-32 metric ton	EI v3	2014	Global
Forklift	Transport, lorry, 16-32 metric ton	EI v3	2014	Global
Tanker truck	Transport, lorry, 16-32 metric ton	EI v3	2014	Global
Box truck	Transport, lorry, 16-32 metric ton	EI v3	2014	Global
Boat	Transport, freight, sea	EI v3	2014	Global

3.4.4. Disposal

Disposal processes were obtained from the EcoInvent database. These processes were chosen to correspond to the materials being disposed, which are packaging materials. Since these materials do not decompose in a landfill, there are no energy recovery credits from landfill gas capture and combustion. The 'Inert waste, for final disposal' data set was used for the packaging material. Table 3.4.5 reviews the relevant disposal dataset used in the model.

Table 3.4.4 Key disposal datasets used in inventory analysis

Material disposed	Dataset name	Primary source	Year	Geography
Plastic bag	Inert waste, for final disposal	EI v3	2014	Global
PE film	Inert waste, for final disposal	EI v3	2014	Global
Product	Inert waste, for final disposal	EI v3	2014	Global

3.4.5. Emissions to air, water, and soil

ICC reported no emissions to air, water, or soil. There is a machine in the ICC facility that has a dust collector which captures and reprocesses the dust, preventing dust emissions.

3.5 Limitations

Cellulose insulation is assumed to have a reference service life equal to that of the building [4]. Thus, for example if the building has a 75-year service life, the insulation is likewise assumed to last 75 years with no maintenance. Although the building envelope thermal insulation PCR requires a functional unit of $R_{SI} = 1\ m^2 \cdot K/W$ [1], it should be noted that a product with this R-value is not sold by ICC. The declared product is delivered to the site of installation with the R-value chosen by the customer.

LCA results for the products represent production volumes for the Houston, TX facility.

Proxy data used in the LCA model were limited to background data for raw material production. US background data were used whenever possible, with European or global data substituted as proxies as necessary.

3.6 Criteria for the exclusion of inputs and outputs

All energy and material flow data available were included in the model and comply with the UL PCR cut-off criteria. None of the data that was provided needed to be excluded by the cut-off rules [1].

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

- All inputs and outputs to a (unit) process shall be included in the calculation of the pre-set parameters results, for which data are available. Data gaps shall be filled by conservative assumptions with average, generic or proxy data. Any assumptions for such choices shall be documented.
- Particular care should be taken to include material and energy flows that are known or suspected to release substances into the air, water or soil in quantities that contribute significantly to any of the pre-set indicators of this document. In cases of insufficient input data or data gaps for a unit process, the cut-off criteria shall be 1 % of renewable primary resource (energy), 1 % nonrenewable primary resource (energy) usage, 1 % of the total mass input of that unit process and 1 % of environmental impacts. The total of neglected input flows per module shall be a maximum of 5 % of energy usage, mass and environmental impacts. When assumptions are used in combination with plausibility considerations and expert judgement to demonstrate compliance with these criteria, the assumptions shall be conservative.
- All substances with hazardous and toxic properties that can be of concern for human health and/or the environment shall be identified and declared according to normative requirements in standards or regulation applicable in the market for which the EPD is valid, even though the given process unit is under the cut-off criterion of 1 % of the total mass.

In this report, no known flows are deliberately excluded; therefore, these criteria have been met. The completeness of the bill of materials defined in this report satisfies the above defined cut-off criteria.

3.7 Allocation

Whenever a system boundary is crossed, environmental inputs and outputs have to be assigned to the different products. Where multi-inputs or multi-outputs are considered, the same applies. The PCR prescribes to report where and how allocation occurs in the modeling of the LCA.

No allocation was necessary in this project. ICC provided data for four different products from one facility. All the data provided was specific to each product.

3.8 Software and database

The LCA model was created using SimaPro Analyst 8.5.2.0 for life cycle engineering. The EcoInvent LCI data sets from version numbers listed in section 3.4 provide the life cycle inventory data of most of the raw materials and processes for modeling the products.

3.9 Critical review

This is a supporting LCA report for cellulose insulation products Transparency Reports and will be evaluated for conformance to the PCR according to ISO 14025 [5] and the ISO 14040/14044 standards [6].

4 IMPACT ASSESSMENT METHODS

4.1 Impact assessment

The environmental indicators as required by the PCRs are included as well as other indicators required to use the SM2013 Methodology [7] (see Table 4.1). The impact indicators are derived using the 100-year time horizon[1] factors, where relevant, as defined by TRACI 2.1 classification and characterization [8]. Long-term emissions (> 100 years) are not taken into consideration in the impact estimate. USEtox indicators are used to evaluate ecotoxicity, results will be reported only as a contribution analysis. This follows the approach from the PCRs.

Table 4.1 Selected impact categories and units

Impact category	Unit
Acidification	kg SO_2 eq (sulphur dioxide)
Ecotoxicity	CTUe
Eutrophication	kg N eq (nitrogen)
Global warming	kg CO_2 eq (carbon dioxide)
Ozone depletion	kg CFC-11 eq
Carcinogenics	CTUh
Non-carcinogenics	CTUh
Respiratory effects	kg PM2.5 eq (fine particulates)
Smog	kg O_3 eq (ozone)
Fossil fuel depletion	MJ surplus

With respect to global warming potential, biogenic carbon is included in impact category calculations.

It shall be noted that the above impact categories represent impact potentials. They are approximations of environmental impacts that could occur if the emitted molecules would follow the underlying impact pathway and meet certain conditions in the receiving environment while doing so. In addition, the inventory only captures that fraction of the total environmental load that corresponds to the chosen functional unit (relative approach).

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.

4.2 Normalization and weighting

To arrive to a single score indicator, normalization [9] and weighting [10] conforming to the SM2013 Methodology were applied.

[1] The 100-year period relates to the period in which the environmental impacts are modeled. This is different from the time period of the functional unit. The two periods are related as follows: all environmental impacts that are created in the period of the functional unit are modeled through life cycle impact assessment using a 100-year time horizon to understand the impacts that take place.

Table 4.2 Normalization and Weighting factors

Impact category	Normalization	Weighting (%)
Acidification	90.9	3.6
Ecotoxicity	11000	8.4
Eutrophication	21.6	7.2
Global warming	24200	34.9
Ozone depletion	0.161	2.4
Carcinogenics	5.07E-05	9.6
Non carcinogenics	1.05E-03	6.0
Respiratory effects	24.3	10.8
Smog	1390	4.8
Fossil fuel depletion	17300	12.1

5 ASSESSMENT AND INTERPRETATION

This chapter includes the results from the LCA for the products studied. It details the results per product per functional unit and concludes with recommendations. LCI and LCIA data can be seen in the LCA results spreadsheets [2]. The results are presented per functional unit.

5.1 Resource use and waste flows

Resource use indicators, output flows and waste category indicators, and carbon emissions and removals are presented in this section. LCI flows were calculated with the help of the draft American Center for Life Cycle Assessment guide to the ISO 21930:2017 metrics [11].

Resource use indicators represent the amount of materials consumed to produce not only the insulation itself, but the raw materials, electricity, natural gas, etc. that go into the product's life cycle. Secondary materials used in the production of insulation include mixed recycled papers

Primary energy is an energy form found in nature that has not been subjected to any conversion or transformation process and is expressed in energy demand from renewable and non-renewable resources. Efficiencies in energy conversion are taken into account when calculating primary energy demand from process energy consumption. Water use represents total water used over the entire life cycle. No renewable energy was used in production, and no energy was recovered.

Non-hazardous waste is calculated based on the amount of waste generated during the manufacturing, installation, and disposal life cycle stages. There is no hazardous or radioactive waste associated with the life cycle. Additionally, all materials are assumed to be landfilled rather than incinerated or reused/recycled, so no materials are available for energy recovery or reuse/recycling. Waste occurs at product end-of-life when it is disposed to a landfill.

The biogenic carbon content was reported for each module. The biogenic content emissions and removals were due to cardboard and paper bags. Cardboard can be a product ingredient and paper bags are used for raw material packaging for some companies. These are both bio-based materials.

Tables 5.1a-d show resource use, output and waste flows, and carbon emissions and removals for all insulation products per functional unit.

Table 5.1a Resource use, output and waste flows, and carbon emissions and removals for K13 & Thermocon Insulation per functional unit [2]

	Unit	A1-A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4
Resource use indicators															
Renewable primary energy used as energy carrier (fuel)	MJ, LHV	3.47E-01	5.98E-02	1.34E-01	0	0	0	0	0	0	0	0	5.86E-03	0	3.21E-03
Renewable primary resources with energy content used as material	MJ, LHV	1.96E-01	0	3.77E-02	0	0	0	0	0	0	0	0	0	0	0
Total use of renewable primary resources with energy content	MJ, LHV	5.43E-01	5.98E-02	1.72E-01	0	0	0	0	0	0	0	0	5.86E-03	0	3.21E-03
Non-renewable primary resources used as an energy carrier (fuel)	MJ, LHV	2.92E+01	9.66E+00	7.04E+00	0	0	0	0	0	0	0	0	9.46E-01	0	4.61E-01
Non-renewable primary resources with energy content used as material	MJ, LHV	1.58E-01	0	0	0	0	0	0	0	0	0	0	0	0	0
Total use of non-renewable primary resources with energy content	MJ, LHV	2.94E+01	9.66E+00	7.04E+00	0	0	0	0	0	0	0	0	9.46E-01	0	4.61E-01
Secondary materials	kg	1.18E+00	0	0	0	0	0	0	0	0	0	0	0	0	0
Renewable secondary fuels	MJ, LHV	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-renewable secondary fuels	MJ, LHV	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Recovered energy	MJ, LHV	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Use of net fresh water resources	m3	3.03E+00	6.61E-01	5.58E-01	0	0	0	0	0	0	0	0	6.47E-02	0	3.49E-02
Output flows and waste category indicators															
Hazardous waste disposed	kg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-hazardous waste disposed	kg	0	0	3.57E-02	0	0	0	0	0	0	0	0	0	0	2.15E+00
High-level radioactive waste, conditioned, to final repository	kg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Components for re-use	kg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Materials for recycling	kg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Materials for energy recovery	kg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Exported energy	MJ, LHV	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon emissions and removals															
Biogenic Carbon Removal from Product	kg CO_2	1.51E-05	0	0	0	0	0	0	0	0	0	0	0	0	0

Biogenic Carbon Emission from Product	kg CO_2	1.37E-02	0	0	0	0	0	0	0	0	0	0	0	0	4.71E-04
Biogenic Carbon Removal from Packaging	kg CO_2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biogenic Carbon Emission from Packaging	kg CO_2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biogenic Carbon Emission from Combustion of Waste from Renewable Sources Used in Production Processes	kg CO_2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calcination Carbon Emissions	kg CO_2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbonation Carbon Removals	kg CO_2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon Emissions from Combustion of Waste from Non-Renewable Sources used in Production Processes	kg CO_2	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 5.1b Resource use, output and waste flows, and carbon emissions and removals for Ure-K Insulation per functional unit [2]

	Unit	A1-A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4
Resource use indicators															
Renewable primary energy used as energy carrier (fuel)	MJ, LHV	3.73E-01	8.03E-02	1.80E-01	0	0	0	0	0	0	0	0	7.86E-03	0	4.31E-03
Renewable primary resources with energy content used as material	MJ, LHV	2.46E-01	0	5.05E-02	0	0	0	0	0	0	0	0	0	0	0
Total use of renewable primary resources with energy content	MJ, LHV	6.19E-01	8.03E-02	2.31E-01	0	0	0	0	0	0	0	0	7.86E-03	0	4.31E-03
Non-renewable primary resources used as an energy carrier (fuel)	MJ, LHV	3.42E+01	1.30E+01	9.45E+00	0	0	0	0	0	0	0	0	1.27E+00	0	6.19E-01
Non-renewable primary resources with energy content used as material	MJ, LHV	3.63E-04	0	0	0	0	0	0	0	0	0	0	0	0	0
Total use of non-renewable primary resources with energy content	MJ, LHV	3.42E+01	1.30E+01	9.45E+00	0	0	0	0	0	0	0	0	1.27E+00	0	6.19E-01
Secondary materials	kg	1.59E+00	0	0	0	0	0	0	0	0	0	0	0	0	0
Renewable secondary fuels	MJ, LHV	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-renewable secondary fuels	MJ, LHV	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Recovered energy	MJ, LHV	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Use of net fresh water resources	m3	4.06E+00	8.87E-01	7.48E-01	0	0	0	0	0	0	0	0	8.69E-02	0	4.63E-02
Output flows and waste category indicators															
Hazardous waste disposed	kg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-hazardous waste disposed	kg	0	0	4.79E-02	0	0	0	0	0	0	0	0	0	0	2.89E+00
High-level radioactive waste, conditioned, to final repository	kg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Components for re-use	kg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Materials for recycling	kg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Materials for energy recovery	kg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Exported energy	MJ, LHV	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon emissions and removals															
Biogenic Carbon Removal from Product	kg CO_2	2.81E-05	0	0	0	0	0	0	0	0	0	0	0	0	0

Biogenic Carbon Emission from Product	kg CO_2	1.73E-02	0	0	0	0	0	0	0	0	0	0	0	0	6.31E-04
Biogenic Carbon Removal from Packaging	kg CO_2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biogenic Carbon Emission from Packaging	kg CO_2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biogenic Carbon Emission from Combustion of Waste from Renewable Sources Used in Production Processes	kg CO_2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calcination Carbon Emissions	kg CO_2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbonation Carbon Removals	kg CO_2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon Emissions from Combustion of Waste from Non-Renewable Sources used in Production Processes	kg CO_2	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 5.1c Resource use, output and waste flows, and carbon emissions and removals for SonaSpray "fc" & ThermoCon FC Insulation per functional unit [2]

	Unit	A1-A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4
Resource use indicators															
Renewable primary energy used as energy carrier (fuel)	MJ, LHV	7.44E-01	1.18E-01	2.66E-01	0	0	0	0	0	0	0	0	1.16E-04	0	6.35E-03
Renewable primary resources with energy content used as material	MJ, LHV	3.94E-01	0	7.44E-02	0	0	0	0	0	0	0	0	0	0	0
Total use of renewable primary resources with energy content	MJ, LHV	1.14E+00	1.18E-01	3.40E-01	0	0	0	0	0	0	0	0	1.16E-04	0	6.35E-03
Non-renewable primary resources used as an energy carrier (fuel)	MJ, LHV	6.10E+01	1.91E+01	1.39E+01	0	0	0	0	0	0	0	0	1.87E-02	0	9.12E-01
Non-renewable primary resources with energy content used as material	MJ, LHV	4.95E-04	0	0	0	0	0	0	0	0	0	0	0	0	0
Total use of non-renewable primary resources with energy content	MJ, LHV	6.10E+01	1.91E+01	1.39E+01	0	0	0	0	0	0	0	0	1.87E-02	0	9.12E-01
Secondary materials	kg	2.33E+00	0	0	0	0	0	0	0	0	0	0	0	0	0
Renewable secondary fuels	MJ, LHV	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-renewable secondary fuels	MJ, LHV	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Recovered energy	MJ, LHV	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Use of net fresh water resources	m3	6.58E+00	1.31E+00	1.10E+00	0	0	0	0	0	0	0	0	1.28E-03	0	6.89E-02
Output flows and waste category indicators															
Hazardous waste disposed	kg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-hazardous waste disposed	kg	0	0	7.05E-02	0	0	0	0	0	0	0	0	0	0	4.25E+00
High-level radioactive waste, conditioned, to final repository	kg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Components for re-use	kg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Materials for recycling	kg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Materials for energy recovery	kg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Exported energy	MJ, LHV	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon emissions and removals															
Biogenic Carbon Removal from Product	kg CO_2	3.22E-05	0	0	0	0	0	0	0	0	0	0	0	0	0

Biogenic Carbon Emission from Product	kg CO_2	2.58E-02	0	0	0	0	0	0	0	0	0	0	0	0	9.30E-04
Biogenic Carbon Removal from Packaging	kg CO_2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biogenic Carbon Emission from Packaging	kg CO_2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biogenic Carbon Emission from Combustion of Waste from Renewable Sources Used in Production Processes	kg CO_2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calcination Carbon Emissions	kg CO_2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbonation Carbon Removals	kg CO_2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon Emissions from Combustion of Waste from Non-Renewable Sources used in Production Processes	kg CO_2	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 5.1d Resource use, output and waste flows, and carbon emissions and removals for SonaKrete & ThermoCon TR Insulation per functional unit [2]

	Unit	A1-A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4
Resource use indicators															
Renewable primary energy used as energy carrier (fuel)	MJ, LHV	6.97E-01	1.18E-01	1.40E+00	0	0	0	0	0	0	0	0	1.16E-04	0	6.35E-03
Renewable primary resources with energy content used as material	MJ, LHV	3.64E-01	0	2.84E-01	0	0	0	0	0	0	0	0	0	0	0
Total use of renewable primary resources with energy content	MJ, LHV	1.06E+00	1.18E-01	1.69E+00	0	0	0	0	0	0	0	0	1.16E-04	0	6.35E-03
Non-renewable primary resources used as an energy carrier (fuel)	MJ, LHV	5.35E+01	1.91E+01	7.22E+01	0	0	0	0	0	0	0	0	1.87E-02	0	9.12E-01
Non-renewable primary resources with energy content used as material	MJ, LHV	4.56E-04	0	0	0	0	0	0	0	0	0	0	0	0	0
Total use of non-renewable primary resources with energy content	MJ, LHV	5.35E+01	1.91E+01	7.22E+01	0	0	0	0	0	0	0	0	1.87E-02	0	9.12E-01
Secondary materials	kg	2.34E+00	0	0	0	0	0	0	0	0	0	0	0	0	0
Renewable secondary fuels	MJ, LHV	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-renewable secondary fuels	MJ, LHV	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Recovered energy	MJ, LHV	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Use of net fresh water resources	m3	6.07E+00	1.31E+00	3.20E+00	0	0	0	0	0	0	0	0	1.28E-03	0	6.89E-02
Output flows and waste category indicators															
Hazardous waste disposed	kg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-hazardous waste disposed	Kg	0	0	1.72E-01	0	0	0	0	0	0	0	0	0	0	4.25E+00
High-level radioactive waste, conditioned, to final repository	kg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Components for re-use	kg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Materials for recycling	kg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Materials for energy recovery	kg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Exported energy	MJ, LHV	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon emissions and removals															
Biogenic Carbon Removal from Product	kg CO_2	1.08E-04	0	0	0	0	0	0	0	0	0	0	0	0	0
Biogenic Carbon Emission from Product	kg CO_2	2.35E-02	0	0	0	0	0	0	0	0	0	0	0	0	9.30E-04

Biogenic Carbon Removal from Packaging	kg CO_2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biogenic Carbon Emission from Packaging	kg CO_2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biogenic Carbon Emission from Combustion of Waste from Renewable Sources Used in Production Processes	kg CO_2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calcination Carbon Emissions	kg CO_2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbonation Carbon Removals	kg CO_2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon Emissions from Combustion of Waste from Non-Renewable Sources used in Production Processes	kg CO_2	0	0	0	0	0	0	0	0	0	0	0	0	0	0

5.2 Life cycle impact assessment (LCIA)

It shall be reiterated at this point that the reported impact categories represent impact potentials; they are approximations of environmental impacts that could occur if the emitted molecules would follow the underlying impact pathway and meet certain conditions in the receiving environment while doing so. In addition, the inventory only captures that fraction of the total environmental load that corresponds to the chosen functional unit (relative approach). LCIA results are therefore relative expressions only and do not predict actual impacts on category endpoints, the exceeding of thresholds, safety margins, or risks.

Life cycle impact assessment (LCIA) results are shown for ICC's insulation products. Unlike life cycle inventories, which only report sums for individual inventory flows, the LCIA includes a classification of individual emissions with regard to the impacts they are associated with and subsequently a characterization of the emissions by a factor expressing their respective contribution to the impact category indicator. The end result is a single metric for quantifying each potential impact, such as "Global Warming Potential".

The impact assessment results are calculated using characterization factors published by the United States Environmental Protection Agency. The TRACI 2.1 (Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts 2.1) methodology is the most widely applied impact assessment method for U.S. LCA studies. USEtox indicators are used to evaluate ecotoxicity, results will be reported only as a contribution analysis.The SM2013 Methodology is also applied to come up with single score results.

The six impact categories required by the PCR are globally deemed mature enough to be included in Type III environmental declarations. Other categories are being developed and defined and LCA should continue making advances in their development; however, the EPD users shall not use additional measures for comparative purposes. Impact categories which were not required by the PCR are included in part to allow for the calculation of millipoints using the SM2013 Methodology, but it should be noted that there are known limitations related to these impact categories due to their high degree of uncertainty.

5.2.1. K-13 & ThermoCon Insulation

Tables 5.2.1a shows the contributions of each stage of the life cycle for K-13 & ThermoCon insulation.

For this insulation, the raw material acquisition and manufacturing stages (A1-A3) dominate the results for all impact categories except for ecotoxicity, where the transportation stage dominates. Following these two stages, the next highest impacts come from the construction and installation stage (A5), which have a similar contribution. The impact of the raw material acquisition and manufacturing stages are mostly due to the raw material ingredients. Some raw material ingredients such as boric acid and ethylene vinyl acetate copolymer (data set used for PVA) have slightly higher impacts than other ingredients. The contributions to outbound transportation are casued by the use of trucks. The landfilling of the discarded product contributes to the disposal stage. The impacts associated with installation and maintenance are due to the disposal of packaging waste and the installation of the insulation using a blowing machine.

Certain raw materials such as boric acid and ethylene vinyl acetate copolymer are the main contributors to the raw material acquisition stage. Raw material inbound transportation is a small contributor to the impacts for this stage.

Table 5.2.1a K-13 & ThermoCon Insulation impact potential results per functional unit [2]

Impact category	**Unit**	A1-A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4
Acidification	kg SO_2 eq	8.35E-03	2.25E-03	2.15E-03	0	0	0	0	0	0	0	0	2.21E-04	0	1.48E-04
Eutrophication	kg N eq	1.03E-03	3.21E-04	7.99E-04	0	0	0	0	0	0	0	0	3.14E-05	0	1.70E-05
Global warming	kg CO_2 eq	1.37E+00	6.03E-01	4.25E-01	0	0	0	0	0	0	0	0	5.90E-02	0	1.86E-02
Ozone depletion	kg CFC-11 eq	1.73E-07	1.46E-07	6.29E-08	0	0	0	0	0	0	0	0	1.43E-08	0	6.71E-09
Carcinogenics	CTUh	1.27E-08	4.40E-09	2.81E-09	0	0	0	0	0	0	0	0	4.31E-10	0	1.77E-10
Non-carcinogenics	CTUh	1.49E-07	1.30E-07	2.62E-08	0	0	0	0	0	0	0	0	1.27E-08	0	1.78E-09
Respiratory effects	kg PM2.5 eq	1.19E-03	4.09E-04	1.80E-04	0	0	0	0	0	0	0	0	4.00E-05	0	1.81E-05
Smog	kg O_3 eq	9.75E-02	4.58E-02	2.93E-02	0	0	0	0	0	0	0	0	4.48E-03	0	3.54E-03
Fossil fuel depletion	MJ, LHV	3.30E+00	1.23E+00	5.80E-01	0	0	0	0	0	0	0	0	1.20E-01	0	5.82E-02

Additional Environmental Information	**Unit**	A1-A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4
Freshwater ecotoxicity	%	89%	7%	3%	0	0	0	0	0	0	0	0	1%	0	0%

Single score results

The SM millipoint score by life cycle phase for this product is presented below (Table 5.2.1b). They do not conflict with the trends in the results using the impact assessment results before normalization and weighting.

Table 5.2.1b Averaged SM millipoint scores for K-13 & ThermoCon Insulation by life cycle stage per functional unit [2]

Impact category	**Unit**	Raw material acquisition and manufacturing	Transportation	Installation and maintenance	Transportation	Disposal
		A1-A3	A4	A5, B1-B7	C2	C4
SM single figure score	mPts	**1.05E-04**	**5.70E-05**	**2.50E-05**	**5.58E-06**	**1.62E-06**

5.2.2. Ure-K Insulation

Table 5.2.2a shows the contributions of each stage of the life cycle for Ure-K Insulation.

For this insulation, the raw material acquisition and manufacturing stages (A1-A3) dominate the results for all impact categories except for ecotoxicity, where the transportation stage dominates. Following these two stages, the next highest impacts come from the construction and installation stage (A5), which have a similar contribution. The impact of the raw material acquisition and manufacturing stages are mostly due to the raw material ingredients. Some raw material ingredients such as boric acid and ethylene vinyl acetate copolymer (data set used for PVA) have slightly higher impacts than other ingredients. The contributions to outbound transportation are casued by the use of trucks. The landfilling of the discarded product contributes to the disposal stage. The impacts associated with installation and maintenance are due to the disposal of packaging waste and the installation of the insulation using a blowing machine.

Certain raw materials such as boric acid and ethylene vinyl acetate copolymer are the main contributors to the raw material acquisition stage. Raw material inbound transportation is a small contributor to the impacts for this stage.

Table 5.2.2a Ure-K Insulation impact potential results per functional unit [2]

Impact category	**Unit**	A1-A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4
Acidification	kg SO_2 eq	1.11E-02	3.02E-03	2.88E-03	0	0	0	0	0	0	0	0	2.96E-04	0	1.98E-04
Eutrophication	kg N eq	1.38E-03	4.31E-04	1.07E-03									4.22E-05		2.28E-05
Global warming	kg CO_2 eq	1.82E+00	8.09E-01	5.70E-01	0	0	0	0	0	0	0	0	7.92E-02	0	2.49E-02
Ozone depletion	kg CFC-11 eq	2.32E-07	1.95E-07	8.45E-08	0	0	0	0	0	0	0	0	1.91E-08	0	9.01E-09

Carcinogenics	CTUh	1.68E-08	5.91E-09	3.77E-09	0	0	0	0	0	0	0	0	5.79E-10	0	2.37E-10
Non-carcinogenics	CTUh	1.97E-07	1.74E-07	3.52E-08	0	0	0	0	0	0	0	0	1.70E-08	0	2.39E-09
Respiratory effects	kg PM2.5 eq	1.58E-03	5.48E-04	2.41E-04	0	0	0	0	0	0	0	0	5.37E-05	0	2.42E-05
Smog	kg O_3 eq	1.30E-01	6.15E-02	3.93E-02	0	0	0	0	0	0	0	0	6.02E-03	0	4.75E-03
Fossil fuel depletion	MJ, LHV	4.39E+00	1.65E+00	7.79E-01	0	0	0	0	0	0	0	0	1.61E-01	0	7.81E-02

Additional Environmental Information	**Unit**	A1-A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4
Freshwater ecotoxicity	%	89%	7%	3%	0	0	0	0	0	0	0	0	1%	0	0%

Single score results

The SM millipoint score by life cycle phase for this product is presented below (Table 5.2.2b). They do not conflict with the trends in the results using the impact assessment results before normalization and weighting.

Table 5.2.2b SM millipoint scores for Ure-K Insulation by life cycle stage per functional unit [2]

Impact category	**Unit**	Raw material acquisition and manufacturing	Transportation	Installation and maintenance	Transportation	Disposal
		A1-A3	A4	A5, B1-B7	C2	C4
SM single figure score	mPts	**1.40E-04**	**7.64E-05**	**3.36E-05**	**7.49E-06**	**2.18E-06**

5.2.3. SonaSpray "fc" & ThermoCon FC Insulation

Table 5.2.3a shows the contributions of each stage of the life cycle for SonaSpray "fc" & ThermoCon FC Insulation.

For this insulation, the raw material acquisition and manufacturing stages (A1-A3) dominate the results for all impact categories except for ozone depletion, non-carcinogenics, and smog. The transportation stage dominates for the ozone depletion and non-carcinogenics categories while the construction and installation stage dominates the smog category. Following the raw material acquisition and manufacturing stage and the transportation stage, the next highest impacts come from the construction and installation stage (A5), which have a similar contribution. The impact of the raw material acquisition and manufacturing stages are mostly due to the raw material ingredients. Some raw material ingredients such as boric acid and ethylene vinyl acetate copolymer (data set used for PVA) have slightly higher impacts than other ingredients. The contributions to outbound transportation are casued by the use of trucks. The landfilling of the discarded product contributes to the disposal stage. The impacts associated with installation and maintenance are due to the disposal of packaging waste and the installation of the insulation using a blowing machine.

Certain raw materials such as boric acid and ethylene vinyl acetate copolymer are the main contributors to the raw material acquisition stage. Raw material inbound transportation is a small contributor to the impacts for this stage.

Table 5.2.3a SonaSpray "fc" & ThermoCon FC Insulation impact potential results per functional unit [2]

Impact category	**Unit**	A1-A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4
Acidification	kg SO_2 eq	2.12E-02	4.45E-03	4.24E-03	0	0	0	0	0	0	0	0	4.36E-06	0	2.92E-04
Eutrophication	kg N eq	2.11E-03	6.35E-04	1.58E-03	0	0	0	0	0	0	0	0	6.22E-07	0	3.36E-05
Global warming	kg CO_2 eq	2.70E+00	1.19E+00	8.39E-01	0	0	0	0	0	0	0	0	1.17E-03	0	3.67E-02
Ozone depletion	kg CFC-11 eq	2.99E-07	2.88E-07	1.24E-07	0	0	0	0	0	0	0	0	2.82E-10	0	1.33E-08
Carcinogenics	CTUh	2.49E-08	8.71E-09	5.55E-09	0	0	0	0	0	0	0	0	8.53E-12	0	3.50E-10
Non-carcinogenics	CTUh	2.09E-07	2.56E-07	5.17E-08	0	0	0	0	0	0	0	0	2.51E-10	0	3.53E-09
Respiratory effects	kg PM2.5 eq	2.53E-03	8.08E-04	3.55E-04	0	0	0	0	0	0	0	0	7.91E-07	0	3.57E-05
Smog	kg O_3 eq	2.48E-01	9.05E-02	5.78E-02	0	0	0	0	0	0	0	0	8.87E-05	0	7.00E-03
Fossil fuel depletion	MJ, LHV	6.87E+00	2.42E+00	1.15E+00	0	0	0	0	0	0	0	0	2.37E-03	0	1.15E-01

Additional Environmental Information	**Unit**	A1-A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4
Freshwater ecotoxicity	%	100%	0%	0%	0	0	0	0	0	0	0	0	0%	0	0%

Single score results

The SM millipoint score by life cycle phase for this product is presented below (Table 5.2.3b). They do not conflict with the trends in the results using the impact assessment results before normalization and weighting.

Table 5.2.3b SM millipoint scores for SonaSpray "fc" & ThermoCon FC Insulation by life cycle stage per functional unit [2]

Impact category	Unit	Raw material acquisition and manufacturing	Transportation	Installation and maintenance	Transportation	Disposal
		A1-A3	A4	A5, B1-B7	C2	C4
SM single figure score	mPts	**1.96E-04**	**1.13E-04**	**4.94E-05**	**1.10E-07**	**3.21E-06**

5.2.4. SonaKrete & ThermoCon TR Insulation

Table 5.2.4a shows the contributions of each stage of the life cycle for SonaKrete & ThermoCon TR Insulation.

For this insulation, the raw material acquisition and manufacturing stages (A1-A3) and the construction and installation stage (A5) dominate the results for all impact categories except for non-carcinogenics and ecotoxicity where the transportation stage dominates. The raw material acquisition and manufacturing stages (A1-A3) dominate carcinogenics, respiratory effects, smog, and fossil fuel depletion. The construction and installation stage dominates acidification, eutrophication, global warming, and ozone depletion. The impact of the raw material acquisition and manufacturing stages are mostly due to the raw material ingredients. Some raw material ingredients such as boric acid and ethylene vinyl acetate copolymer (data set used for PVA) have slightly higher impacts than other ingredients. The contributions to outbound transportation are casued by the use of trucks. The landfilling of the discarded product contributes to the disposal stage. The impacts associated with installation and maintenance are due to the disposal of packaging waste and the installation of the insulation using a blowing machine.

Certain raw materials such as boric acid and ethylene vinyl acetate copolymer are the main contributors to the raw material acquisition stage. Raw material inbound transportation is a small contributor to the impacts for this stage.

Table 5.2.4a SonaKrete & ThermoCon TR impact potential results per functional unit [2]

Impact category	**Unit**	A1-A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4
Acidification	kg SO_2 eq	2.02E-02	4.45E-03	1.89E-02	0	0	0	0	0	0	0	0	4.36E-06	0	2.92E-04
Eutrophication	kg N eq	2.01E-03	6.35E-04	2.93E-03	0	0	0	0	0	0	0	0	6.22E-07	0	3.36E-05
Global warming	kg CO_2 eq	2.46E+00	1.19E+00	4.25E+00	0	0	0	0	0	0	0	0	1.17E-03	0	3.67E-02
Ozone depletion	kg CFC-11 eq	2.74E-07	2.88E-07	5.48E-07	0	0	0	0	0	0	0	0	2.82E-10	0	1.33E-08
Carcinogenics	CTUh	2.24E-08	8.71E-09	1.68E-08	0	0	0	0	0	0	0	0	8.53E-12	0	3.50E-10
Non-carcinogenics	CTUh	1.92E-07	2.56E-07	1.51E-07	0	0	0	0	0	0	0	0	2.51E-10	0	3.53E-09

Respiratory effects	kg PM2.5 eq	2.37E-03	8.08E-04	1.25E-03	0	0	0	0	0	0	0	0	7.91E-07	0	3.57E-05
Smog	kg O_3 eq	2.37E-01	9.06E-02	1.60E-01	0	0	0	0	0	0	0	0	8.87E-05	0	7.00E-03
Fossil fuel depletion	MJ, LHV	5.95E+00	2.42E+00	5.31E+00	0	0	0	0	0	0	0	0	2.37E-03	0	1.15E-01

Additional Environmental Information	**Unit**	A1-A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4
Freshwater ecotoxicity	%	22%	2%	77%	0	0	0	0	0	0	0	0	0%	0	0%

Single score results

The SM millipoint score by life cycle phase for this product is presented below (Table 5.2.4b). They do not conflict with the trends in the results using the impact assessment results before normalization and weighting.

Table 5.2.4b SM millipoint scores for SonaKrete & ThermoCon TR by life cycle stage per functional unit [2]

Impact category	**Unit**	Raw material acquisition and manufacturing	Transportation	Installation and maintenance	Transportation	Disposal
		A1-A3	A4	A5, B1-B7	C2	C4
SM single figure score	mPts	**1.77E-04**	**1.13E-04**	**1.81E-04**	**1.10E-07**	**3.21E-06**

5.3 Overview of relevant findings

This study assessed a multitude of inventory and environmental indicators. The overall results are consistent with expectations for insulation products' life cycles, as these products are not associated with energy consumption during their use stage. The primary finding, across the environmental indicators and for the products considered, was that raw material acquisition and the manufacturing stages (A1-A3) dominate the impacts with the exception of SonaKrete & ThermoCon TR where the raw material acquisition and the manufacturing stages (A1-A3) and the construction and installation stage (A5) equally dominate the impacts.

Transportation of the final products to distribution facilities (A4) is the second highest contributor for the impact categories. The impact associated with outbound transport is consistently higher than that for inbound transport due to the further transportation distances as well as lower capacity utilization rates.

Installation accounts for a small fraction of overall life cycle impact except for SonaKrete & ThermoCon TR. The installation impacts are associated with packaging disposal and the water and electricity used for an installtion blower machine. There is no impact associated with the use stage. While insulation can influence building energy performance, this aspect is assumed to be 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. No replacements are necessary; therefore, results represent the production of one square meter of insulation at a thickness defined by the functional unit.

At the end of life, insulation is removed from the building and landfilled. For all products, waste was dominated by the final disposal of the product. Non-hazardous waste also accounts for waste generated during manufacturing and installation. No hazardous waste is created by the product system.

5.4 Discussion on data quality

Inventory data quality is judged by its precision (measured, calculated or estimated), completeness (e.g., unreported emissions), consistency (degree of uniformity of the methodology applied on a study serving as a data source), and representativeness (geographical, temporal, and technological).

To cover these requirements and to ensure reliable results, first-hand industry data in combination with consistent background LCA information from SimaPro Analyst 8.5.2.0. The EcoInvent LCI and NERC datasets were used.

Precision and completeness

- Precision: As the relevant foreground data is primary data or modeled based on primary information sources of the owner of the technology, precision is considered to be high. Seasonal variations were balanced out by collecting 12 months of data. All background data are from EcoInvent databases with the documented precision.
- Completeness: Each unit process was checked for mass balance and completeness of the emission inventory. Capital equipment was excluded under cut-off criteria. Otherwise, no data were knowingly omitted.

Consistency and reproducibility

- Consistency: To ensure consistency, all primary data were collected with the same level of detail, while all background data were sourced from the EcoInvent databases. Allocation and other methodological choices were made consistently throughout the model.
- Reproducibility: Reproducibility is warranted as much as possible through the disclosure of input-output data, dataset choices, and modeling approaches in this report. Based on this information, any third party should be able to approximate the results of this study using the same data and modeling approaches.

Representativeness

- Temporal: All primary data were collected for January 2018 through December 2018 in order to ensure representativeness of post-consumer content. All secondary data were obtained from the EcoInvent databases and are typically representative of the years 2008 – 2014.

- Geographical: Primary data are representative of CIMA's production in the US and Canada. Differences in electric grid mix are taken into account with appropriate secondary data. In general, secondary data were collected specific to the country under study. Where country-specific data were unavailable, proxy data were used. Geographical representativeness is considered to be high.
- Technological: All primary and secondary data were modeled to be specific to the technologies under study. Technological representativeness is considered to be high.

5.5 Completeness, sensitivity, and consistency

Completeness
All relevant process steps for each product system were considered and modeled to represent each specific situation. The process chain is considered sufficiently complete with regard to the goal and scope of this study.

Sensitivity
A sensitivity analysis is performed for raw material percentages and SM single figure scores 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. All phases have significant variation due to the process facilities and raw materials used.

Consistency
All assumption, methods, and data were found to be consistent with the study's goal and scope. Differences in background data quality were minimized by using LCI data from the EcoInvent databases. System boundaries, allocation rules, and impact assessment methods have been applied consistently throughout the study.

5.6 Conclusions, limitations, and recommendations

The goal of this study was to conduct a cradle-to grave LCA on ICC insulation products so as to develop SM Transparency Reports. The creation of these Transparency Reports will allow consumers in the building and construction industry to make better informed decisions about the environmental impacts associated with the products they choose. Overall, the study found that environmental performance is driven primarily by cradle-to-gate impact. Raw material acquisition and manufacturing emissions and energy consumption drive environmental performance. The gate-to-grave stages account for minimal contribution to life cycle performance.

The results show that the largest area for reduction of each product's environmental impact is in the raw material acquisition and manufacturing phase. This is an important area for ICC to focus its efforts and one which it can influence.

6 SOURCES

[1] UL Environment, Product Category Rules for preparing an Environmental Product Declaration (EPD) for the Product Category: Part B: Building Envelope Thermal Insulation, v2.0, UL, 2018.

[2] "LCA results spreadsheets", Sustainable Minds, July 2019.

[3] "Primary data spreadsheets", Sustainable Minds, July 2019.

[4] "ICC_correspondence_documentation.pdf", Sustainable Minds, July, 2019.

[5] ISO 14025, "Environmental labels and declarations -- Type III environmental declarations -- Principles and procedures", ISO14025:2006

[6] ISO 14044, "Environmental management - Life cycle assessment - Requirements and guidelines", ISO14044:2006

[7] Joep Meijer, Sustainable Minds SM2013 Methodology and Database, April 25, 2013. For a summary, see the Sustainable Minds single score page: http://www.sustainableminds.com/showroom/shared/learn-single-score.html

[8] Bare, J. 2014. Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts (TRACI) TRACI version 2.1 User's Guide. US EPA Office of Research and Development, Washington, DC, EPA/600/R-12/554, http://nepis.epa.gov/Adobe/PDF/P100HN53.pdf

[9] Ryberg, M., Vieira, M.D.M., Zgola, M. et al. (2014). 'Updated US and Canadian normalization factors for TRACI 2.1.' Clean Technologies and Environmental Policy 16: 329. doi:10.1007/s10098-013-0629-z

[10] Gloria, T. P., B. C. Lippiatt & J. Cooper (2007). 'Life cycle impact assessment weights to support environmentally preferable purchasing in the United States.' Environmental Science & Technology, 41(21), 7551-7557

[11] "ACLCA guide to ISO 21930 metrics.xlsx", draft by ACLCA PCR committee working group for ISO 21930 metric calculation guidance, April 2018.

ACRONYMS

ISO	International Standardization Organization
LCA	life cycle assessment
LCI	life cycle inventory
LCIA	life cycle impact analysis
PCR	Product Category Rule document
TR	Transparency Report™
ULE	UL Environment

GLOSSARY

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

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
close loop & open loop	A closed-loop allocation procedure applies to closed-loop product systems. It also applies to open-loop product systems where no changes occur in the inherent properties of the recycled material. In such cases, the need for allocation is avoided since the use of secondary material displaces the use of virgin (primary) materials. An open-loop allocation procedure applies to open-loop product systems where the material is recycled into other product systems and the material undergoes a change to its inherent properties.
cradle to grave	Addresses the environmental aspects and potential environmental impacts (e.g. use of resources and environmental consequences of releases) throughout a product's life cycle from raw material acquisition until the end of life
cradle to gate	Addresses the environmental aspects and potential environmental impacts (e.g. use of resources and environmental consequences of releases) throughout a product's life cycle from raw material acquisition until the end of the production process ("gate of the factory"). It may also include transportation until use phase
declared unit	quantity of a product for use as a reference unit in an EPD based on one or more information modules
functional unit	quantified performance of a product system for use as a reference unit
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 inventory - LCI	phase of life cycle assessment involving the compilation and quantification of inputs and outputs for a product throughout its life cycle

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

APPENDIX A. USED DATASHEETS

To model the LCA different data sources have been used. This appendix includes a list of all datasheets that have been used:

- LCA results – ICC_LCI
- LCA results – ICC_LCIA
- Primary data_ICC_products