Morin
A Kingspan Group Company

VERIFIED by SCS GLOBAL SERVICES
ENVIRONMENTAL PRODUCT DECLARATION
BASED ON LCA

Declaration Owner

Morin Corporation
685 Middle Street, Bristol, CT 06010
800-640-9501 | www.morincorp.com

Product

Architectural Metal Cladding

Declared Unit

100 m^2 of installed product

EPD Number and Period of Validity

SCS-EPD-09034
EPD Valid: May 26, 2023 through May 25, 2028

Product Category Rule

Part A: Life Cycle Assessment Calculation Rules and Report Requirements. Part B: Insulated Metal Panels, Metal Composite Panels, and Metal Cladding: Roof and Wall Panels, UL 10010–5 (v2.0)

Program Operator

SCS Global Services
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SCSglobal SERVICES

PLANET PASSIONATE

Declaration owner:	Morin Corporation
Address:	685 Middle Street, Bristol, CT 06010
Declaration Number:	SCS-EPD-09034
Declaration Validity Period:	EPD Valid May 26, 2023 through May 25, 2028
Program Operator:	SCS Global Services
Declaration URL Link:	https://www.scsglobalservices.com/certified-green-products-guide
LCA Practitioner:	Sphera
LCA Software and LCI database:	LCA FE 10 CUP 2022.1
Product's Intended Application:	Residential and commercial buildings
Markets of Applicability:	North America
EPD Type:	Product-Specific
EPD Scope:	Cradle-to-Grave
LCIA Method and Version:	IPCC (AR6), TRACI, CML
Independent critical review of the LCA and data, according to ISO 14044 and ISO 14071	☐ internal ☒ external
LCA Reviewer:	Beth Cassese, SCS Global Services
Product Category Rule:	Part A: Part A: Life Cycle Assessment Calculation Rules and Report Requirements (UL Environment, 2022). Part B: Insulated Metal Panels, Metal Composite Panels, and Metal Cladding: Roof and Wall Panels, UL 10010–5 (v2.0) (UL Environment, 2018).
PCR Review conducted by:	Thomas Gloria, PhD, Industrial Ecology Consultants; Lindita Bushi, PhD, Athena Sustainable Materials Institute; Bob Zabcik, P.E., NCI Building Systems
Independent verification of the declaration and data, according to ISO 14025 and the PCR	☐ internal ☒ external
EPD Verifier:	Beth Cassese , SCS Global Services

Declaration Contents:

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

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

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

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

1 Company Description

Established in the early 1960's in Bristol, Connecticut, Morin Corporation (Morin) is the industry leader in architectural metal wall panels and metal roof panels. Morin is part of the Kingspan Group plc., founded in Kingscourt Co. Cavan Ireland in 1965. Kingspan is a global leader in the design, development and
delivery of advanced building envelope products and solutions.

Morin thrive in helping customers bring their most challenging design ideas to life. We offer an extensive suite of metal panel design options including perforations, corners, trimless ends, custom extrusions, and more for a completely customized look. We have a technical team designated to help with drawings, design, and technical know-how for difficult projects. We offer installation support from a team with decades of experience to ensure every project is a success.

2 Product

2.1 Product Description

Utilizing a state-of-the-art roll forming process, products are manufactured accurately and efficiently with volumes of up to 50m square feet each year from our three facilities. Morin offers over hundreds of wall and roof panel options with a wide range of panels with unique profiles including over 30 integrated panels. Our Matrix, Integrity and Pulse series of panels all have interlocking joinery and can be easily integrated. Morin Systems provide for a complete, finished, custom fabricated look. Rounded or miter corners, extrusions, foam backers and custom cut components will make for a more professional looking, longer lasting job. We know we are just one part of many in a project, we want to make our part look its best and have all the tools available from design to installation for you.

The study considered the environmental impacts of two metal cladding products, manufactured by Morin in Bristol CT, Fontana CA, and Deland FL.

- Aluminum architectural metal cladding (22 gauge)
- Steel architectural metal cladding (24 gauge)

The declared unit for this analysis is one hundred square meters (100m^2) of installed cladding.

Package sizes vary based on length; packaging weight is approximately 10% additional weight.

2.2 Application

This declaration covers 22-gauge (0.7 mm) aluminum and 24-gauge (0.55 mm) steel architectural metal cladding. These results are applicable to product thicknesses of 16-29 gauge (1.6-0.34 mm) for aluminum and 18-29 gauge (1.2-0.34 mm) for steel. These products are manufactured by Morin at their facilities situated in Bristol CT, Fontana CA, and Deland FL. The product is intended for use as exterior cladding for buildings.

2.3 Technical Data

Table 1. *Technical properties of the product*

Name	Value	Unit
Length	Aluminum: 1.524 – 9.144 Steel: 1.524 – 9.144	Meters
Width	Aluminum: 0.305 – 1.016 Steel: 0.305 – 1.016	Meters
Thickness	Aluminum: 0.0008128 – 0.00127 Steel: 24 gauge – 18 gauge	Meters

2.4 Delivery Status

The products are made to order and cut to desired pre-specified length.

2.5 Materials Composition

For any questions related to the above methods and tests, please contact Morin at https://www.morincorp.com.

Table 2. *Material content per 100 square meter and as a percent of total mass.*

Material	Aluminum Cladding	Steel Cladding
Aluminum Sheet	99%	0%
Galvanized Steel Sheet	0%	99%
Paint	~1%	~1%
Packaging (plastic, wood, cardboard)	>1%	>1%

2.6 Manufacture

Coils of painted and unpainted metal are purchased from suppliers and transported to each of the production facilities. The coils are slit to the desired panel width, then the profile is formed by the roll forming machine whereby material is continuously and progressively formed from flat sheet shape to the required panel shape. Panels are cut to the required length as specified by the customer and packaged according to specification for the appropriate product. The scrap is recycled outside of Morin.

Material inputs are transported to the Morin facilities by a combination of cargo ship and truck. A protective plastic film is applied to the cladding, then it is packaged on pallets and wrapped in plastic. Finished packaged product is directly to the customer or shipped to a warehouse for storage.

2.6.1 Environment and Health during Manufacture

Morin has created and follows in-house environmental, occupational health and safety, quality, and compliance management systems. These policies have been created in line with the relevant ISO standards and are designed to enhance environmental performance, provide safe and healthy workplaces, enhance customer satisfaction and more. Morin is audited to these policies both internally and externally. Morin is also committed to following the Kingspan Planet Passionate program with aims for Zero Waste to Landfill, reducing the embodied carbon in our products, consuming green energy and harnessing and utilizing rainwater.

There should be no release of hazardous, harmful, or dangerous substances or emissions during the installation and use of metal panel products.

2.7 Product Processing/Installation

Cladding is transported to the installation site in diesel-powered trucks.

2.8 Packaging

Packaging materials are discarded during installation phase and there is no packaging involved at the EOL. Packaging includes protective cardboard, wooden shipping pallets, and plastic film.

2.9 Condition of Use

Per the PCR, the panel is assumed to be washed twice a year and replaced at the end of the reference service life.

2.10 Environment and Health during use

No environmental or health impacts are expected due to normal use of the product.

2.11 Reference Service Life

Per the PCR, the reference service life is 30 years, and the estimated building service life is 75 years. The RSL applies to reference in-use conditions only.

2.12 Extraordinary Effects

No environmental or health impacts are expected due to extraordinary effects including fire and/or water damage and product destruction.

2.13 Re-Use Phase

Waste from installation, replacement, and end of life is assumed to be treated as typical metal construction and demolition (C&D) waste in the US. Per the US EPA, 85% of metal C&D waste is recycled, with the remainder sent to landfill. (US EPA, 2020)

2.14 Disposal

Waste disposed of in landfill is assumed to behave similarly to other metal products.

2.15 Further Information

Further information on the product can be found on the manufacturers' website at www.morincorp.com.

3 LCA: Calculation Rules

3.1 Declared Unit

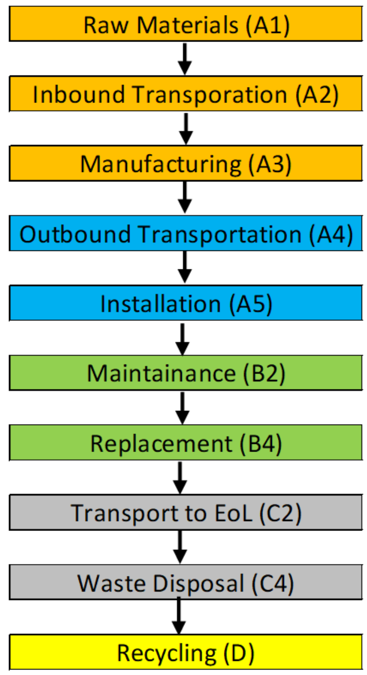
The declared unit used in the study, as specified in the PCR, is 100 m^2 (1076 ft^2) of installed cladding over ESL of 75 years. The cladding is assumed to have a reference service life of 30 years, so over the 75-year building estimated service life, 1.5 replacements will take place.

Table 3. *Declared unit.*

Parameter	Aluminum Cladding	Steel Cladding	Unit
Declared Unit	100 (1076)	100 (1076)	m^2 (ft^2)
Mass	244 (538)	489 (1078)	kg (lbs)
Conversion Factor to 1 kg	0.4	0.2	m^2

3.2 System Boundary

The scope of the EPD is cradle-to-grave, a flow chart is given below:



The following modules are included:

A1-A3 Product Stage

All production-related raw materials and emissions are included from cradle-to-gate, including energy supply and production, raw material extraction and processing, transport of materials to manufacturing site, water use and treatment, and waste processing or recycling of manufacturing waste.

A4 Transport

Transportation of the finished cladding from the manufacturing site to the installation site is included.

A5 Installation

Impacts from the installation of the cladding were calculated, including the disposal or recycling of installation waste and packaging.

B1 Use

There are no impacts associated with this life cycle stage (module).

B2 Maintenance

This includes cleaning of the cladding over its lifetime, per PCR guidelines.

B3 Repair

There are no impacts associated with this life cycle stage (module).

B4 Replacement

This phase represents the impacts of replacing the cladding over the life of the building (75 years). This value is the sum of all impacts, across all lifecycle stages, multiplied by the number of replacements (1.5).

B5 Refurbishment

There are no impacts associated with this life cycle stage (module).

B6-B7 Operational Energy and Water Use

This product does not impact a building's operational energy or water use.

C1 Deconstruction

This phase includes the energy required to deconstruct the cladding.

C2 Transport to End-of-Life

This phase includes the transportation of the flooring product to an end-of-life facility.

C3 Waste Processing

Waste segregation is assumed to occur during deconstruction, and no additional processing is needed before the product is sent to recycling or landfill, therefore this module is declared as zero.

C4 Disposal

The disposal phase includes any impacts associated with the recycling or landfilling of the cladding at the end of its useful life.

D Reuse, Recovery, Recycling Potential

This phase includes benefits and loads beyond the system boundary, such as credits from recycled materials or energy generated from landfill gas combustion.

The system boundary follows modularity and polluter pays principle:

- *"modularity principle": Where processes influence the construction product's environmental performance during its life cycle, they are assigned to the information module of the life cycle stage where they occur; all environmental aspects and potential impacts are declared in the life cycle stage where they can be attributed.*
- *"polluter pays principle": Processes relevant to waste processing are assigned to the product system that generates the waste until the system boundary between product systems is reached.*

3.3 Estimates and Assumptions

No LCI flows were deliberately excluded from this study. PCR guidance was applied in the construction and use stages (distances, maintenance, repair, etc.). Modules B1, B3, B5-7, and C3 are assumed to be zero as they have no LCI impact. Wherever an exact dataset was not found, a proxy dataset was used; details on the proxy data used are given in Section 3.5.

3.4 Cut-off criteria

Cut-off rules as specified per Part A, Section 2.9 were used. All known mass and energy flows are reported and no known flows are deliberately excluded.

3.5 Background Data

As a general rule, specific data derived from specific production processes or average data derived from specific production processes were the first choice as a basis for calculating LCA results. All upstream data have been taken from the Sphera's Managed LCA Content (MLC) (formerly known as GaBi database) 2022.2 database, using LCA FE (formerly known as GaBi), developed and maintained by Sphera. To ensure the highest data quality, all manufacturing data were collected from Morin's Bristol CT, Fontana CA, and Deland FL facilities for the 2021 calendar year. To maximize comparability of results within the LCA, Sphera's Managed LCA Content (MLC) (formerly known as GaBi database) background data were used for energy, transportation, and auxiliary materials.

Table 4. *Data sources for the product system.*

Energy and Fuels					
Energy	**Geography**	**Dataset**	**Data Provider**	**Reference Year**	**Proxy?***
Diesel	US	Diesel mix at refinery	Sphera	2018	No
Electricity	US	Electricity grid mix	Sphera	2019	No
	US	Electricity grid mix - NEWE	Sphera	2019	No
	US	Electricity grid mix - CAMX	Sphera	2019	No
	US	Electricity grid mix - CAMX	Sphera	2019	No
Heavy fuel oil	US	Heavy fuel oil at refinery (0.3wt.% S)	Sphera	2018	No
Thermal energy	US	Thermal energy from diesel	Sphera	2018	No
	US	Thermal energy from natural gas	Sphera	2018	No
	US	Thermal energy from propane	Sphera	2018	No
Raw Materials					
Material	**Geography**	**Dataset**	**Data Provider**	**Reference Year**	**Proxy?***
Aluminum	BH	Aluminum Sheet for Alba/Bahrain	Sphera	2021	No
Aluminum	RME	Aluminum ingot mix	Sphera	2015	No
Steel	RNA	Steel hot dip galvanized	AISI	2017	No
Paint	DE	Polyvinylidene fluoride (PVDF)	Sphera	2021	Geo
	US	Titanium dioxide pigment (sulphate process)	Sphera	2021	No
Plastic Film	US	Biaxial oriented polypropylene film (BOPP)	Sphera	2021	No
Pallets	US	Sawmill lumber softwood	Sphera	2021	No
Cardboard	US	Corrugated product	Sphera	2017	No
Transportation					
Mode / Fuel	**Geography**	**Name**	**Data Provider**	**Reference Year**	**Proxy?***
Truck	US	Truck – TL/dry van (EPA Smartway)	Sphera	2021	No
Ship	GLO	Container Ship, 5,000 to 200,000 dwt payload capacity, ocean going	Sphera	2021	No
End-of-Life					
End-of-life	**Geography**	**Name**	**Data Provider**	**Reference Year**	**Proxy?***
Landfill	US	Municipal solid waste on landfill	Sphera	2021	No
Landfill, steel	US	Ferro metals on landfill	Sphera	2021	No
Landfill, aluminum	US	Glass/inert on landfill	Sphera	2021	No
Landfill, plastic	US	Plastic waste on landfill, post-consumer	Sphera	2021	No
Landfill, wood	US	Untreated wood on landfill, post-consumer	Sphera	2021	No
Landfill, board	US	Paper waste on landfill, post-consumer	Sphera	2021	No
Recycling, steel	GLO	Value of scrap	worldsteel	2021	No
Aluminum	RNA	Aluminum ingot (primary)	Sphera	2016	No
Recycling, aluminum	RNA	Secondary aluminum ingot (95% recycled content)	Aluminum Association	2016	No
Recycling, aluminum	GLO	Aluminum ingot mix	IAI	2015	No
Aluminum	RME	Aluminum ingot mix	Sphera	2015	No
Waste water	US	Municipal waste water treatment (mix)	Sphera	2021	No

* No = no proxy used; Tech = technological proxy; Geo. = geographic proxy

3.6 Data Quality

A variety of tests and checks were performed by the LCA practitioner throughout the project to ensure high quality of the completed LCA. Checks included an extensive review of product specific LCA models as well as the background data used.

Table 5. *Data quality assessment for the product system.*

Data Quality Parameter	Data Quality Discussion
Time-Related Coverage: Age of data and the minimum length of time over which data is collected	The data are intended to represent metal cladding production during the 2021 calendar year. As such, Morin provided primary data for 12 consecutive months during the 2021 calendar year. These data were then used to calculate average production values.
Geographical Coverage: Geographical area from which data for unit processes is collected to satisfy the goal of the study	This background LCA represents Morin's products produced in Bristol CT, Fontana CA, and Deland FL. and sold in the North America. Primary data are representative of the United States. Regionally specific data were used to represent the manufacturing locations' electricity consumption. Geographically accurate data was used to model the production of Aluminum sourced from Bahrain and Steel sourced from North America.
Technology Coverage: **Specific technology or technology mix**	This study is intended to be representative of the manufacturing, use and disposal of metal cladding. All foreground data was collected from Morin and is intended to represent average manufacturing processes in use at their facilities. US aggregated datasets of raw materials were used in this study for majority of the materials, where applicable. In absence of US datasets, EU and DE datasets were used as proxies to fill the data gaps.
Precision: Measure of the variability of the data values for each data expressed	As the majority of the relevant foreground data are measured data or calculated based on primary information sources of the owner of the technology, precision is considered to be high. Seasonal variations were balanced out by using yearly averages. All background data are sourced from Sphera's Managed LCA Content (MLC) (formerly known as GaBi database) with the documented precision.
Completeness: Percentage of flow that is measured or estimated	Each foreground process was checked for mass balance and completeness of the emission inventory. This study omits the use of raw materials packaging, as it represents less than 1% of overall inputs to the product system. Capital goods and infrastructure were also excluded, as they produce millions of units over the course of their life and the impacts attributed to each functional unit of Morin metal panel system is negligible. No other data were knowingly omitted. Completeness of foreground unit process data is considered to be high. All background data are sourced from Sphera's Managed LCA Content (MLC) (formerly known as GaBi database) with the documented completeness.
Representativeness: Qualitative assessment of the degree to which the data set reflects the true population of interest	**Temporal:** All of the primary data is taken from 12 months of continuous operation in the 2021 calendar year. All secondary data were obtained from Sphera's Managed LCA Content (MLC) (formerly known as GaBi database) and published EPDs. Data are representative of the years 2015 to 2021. **Geographical:** All primary and secondary data were collected specific to the region under study. Geographical representativeness is considered to be high. **Technological:** All primary and secondary data were modeled to be specific to the technologies or technology mixes under study. Where technology-specific data were unavailable, proxy data were used. Technological representativeness is considered to be high.
Consistency: Qualitative assessment of whether the study methodology is applied uniformly to the various components of the analysis	All assumptions, methods and data are consistent with each other and with the study's goal and scope. Differences in background data quality were minimized by exclusively using LCI data from Sphera's Managed LCA Content (MLC) (formerly known as GaBi database). System boundaries, allocation rules, and impact assessment methods have been applied consistently throughout the study.
Reproducibility: Qualitative assessment of the extent to which information about the methodology and data values would allow an independent practitioner to reproduce the results reported in the study	Reproducibility is supported 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.
Sources of the Data: Description of all primary and secondary data sources	All primary data were collected using customized data collection templates, which were sent out by email to the respective data providers in the participating companies. Upon receipt, each questionnaire was cross-checked for completeness and plausibility using mass balance, stoichiometry, as well as internal and external benchmarking. If gaps, outliers, or other inconsistencies occurred, Sphera engaged with the data provider to resolve any open issues.
Uncertainty of the Information: Uncertainty related to data, models, and assumptions	The use of proxies constitutes limitations to technological/geographical representativeness. Uncertainty related to materials, paint, energy, packaging product is low.

3.7 Period under review

The period of review is calendar year 2021.

3.8 Allocation

3.8.1 Multi-output allocation

Both products are manufactured in all three locations. An allocation by mass was used to allocate energy and utility in the manufacturing phase (A3) at each location. Resources do not need to be allocated to other products within the plants as the three plant locations manufacture only the Aluminum and Steel cladding products under study (steel and aluminum architectural metal cladding produced by Morin).
Allocation of background data (energy and materials) taken from Sphera's Managed LCA Content (MLC) (formerly known as GaBi database) is documented online at https://sphera.com/life-cycle-assessment-lca-database/

3.8.2 End of life allocation

Per US EPA waste data (US EPA, 2020), the product is modelled as being 85% recycled and 15% landfilled at end of life.
End-of-Life allocation generally follows the requirements of ISO 14044, section 4.3.4.3. Such allocation approaches address the question of how to assign impacts from virgin production processes to material that is recycled and used in future product systems.
Net scrap substitution approach was applied for the metal end of life calculation. The methodology is described below.
Substitution approach– this approach is based on the perspective that material that is recycled into secondary material at end of life is technically able to substitute an equivalent amount of virgin material. Hence, a credit in module D is given to account for this substitutability. To avoid double-counting the benefits of recycled content, waste materials collected for recycling in EOL are first used to satisfy the scrap demand of the manufacturing phase before being sent to recycling and crediting in EOL. This 'net scrap' approach rewards both end of life recycling as well as the use of recycled content.

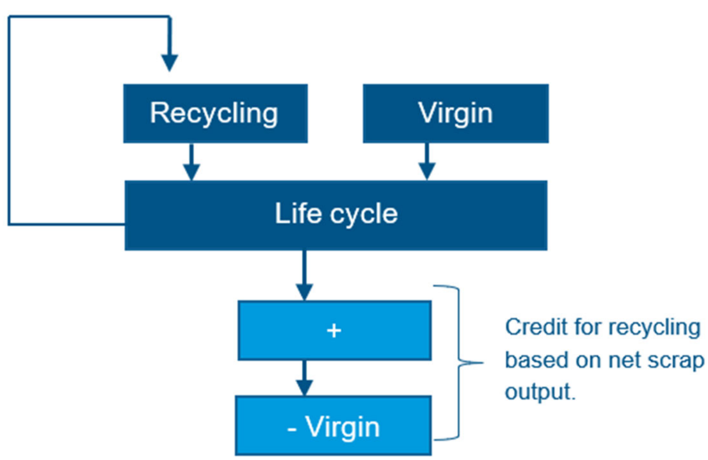


Figure 1. *Representations of the net scrap substitution approach (credit given for net scrap arising)*

For steel, World Steel Association (worldsteel) dataset is used which follows a direct substitution approach with steel scrap following the net scrap methodology. For aluminum, the study applies a net scrap and considers the embodied burden considering the source of the primary material. For instance, in the case of Morin, aluminum is sourced from Bahrain and North America, so the net scrap substitution calculation considers the corresponding embodied burdens (using middle eastern aluminum ingot dataset and North American aluminum ingot dataset respectively).

Primary results are based on the embodied burden approach; however, other results were presented in this report as part of a scenario analysis.

3.9 Comparability

No comparisons or benchmarking is included in this EPD. EPDs from different programs may not be comparable. Full conformance with a PCR allows EPD comparability only when all stages of a life cycle have been considered. However, variations and deviations are possible". Example of variations: Different LCA software and background LCI datasets may lead to differences results for upstream or downstream of the life cycle stages declared.

4 LCA: Scenarios and additional Technical Information

4.1.1 Delivery and Installation stage (A4 - A5)

Final products are distributed via container truck either directly to customers, or first to warehouse, prior to being sent to customers. The table below details distribution assumptions for the cladding product.

Table 6. *Outbound transportation distances.*

Name	Value	Unit
Fuel type	Diesel	
Liters of fuel	67.2	l/100km
Vehicle type	Truck – Dry van	
Transport distance	554	km
Capacity utilization (including empty runs, mass based	55	%
Gross density of products transported	93.64	kg/m^3
Weight of products transported (if gross density not reported)	263.9-527.8	kg
Volume of products transported (if gross density not reported)	5.95	m^3
Capacity utilization volume factor (factor: =1 or <1 or ≥ 1 for compressed or nested packaging products)	<1	-

4.1.2 Installation (A5)

Energy use during installation was modelled per PCR requirements (UL Environment, 2018).
Per PCR, 5% material loss during installation was modelled. Packaging waste and other installation waste were assumed to be following the part A PCR recommendations, given in Table 8 and 9 (UL Environment, 2022).

Table 7. *Installation resources.*

Name	Value (Steel-Al)	Unit
Ancillary materials	--	kg
Net freshwater consumption specified by water source and fate (amount evaporated, amount disposed to sewer)	--	m^3
Other resources	--	kg
Electricity consumption	2	kWh
Other energy carriers - Diesel	3.86 (1)	kg (gallon)
Product loss per functional unit	12.2-24.5	kg
Waste materials at the construction site before waste processing, generated by product installation	19.4-38.7	kg
Output materials resulting from on-site waste processing for recycling	9.17-18.3	kg
Output materials resulting from on-site waste processing for disposal	10.2-20.4	kg
Mass of packaging waste (plastic)	3.12-5.7	kg
Mass of packaging waste (corrugate)	1.3-2.4	kg
Mass of packaging waste (wood)	2.8-5.2	kg
Biogenic carbon contained in packaging	7.45-14.86	kg CO_2
Direct emissions to ambient air, soil and water	--	kg
VOC content	--	µg/m^3

Table 8. *Installation waste disposal assumptions.*

Material type	Recycling rate (%)	Landfill rate (%)	Incineration (%)
Metals	85	15	0
Other Materials	0	100	0

Within the context of the model, the installation step includes all energy used and waste out.

Table 9. *United States disposal rates for packaging materials (A5) according to ULE Part A PCR.*

Material	Material Category	Recycling (%)	Incineration (%)	Landfilling (%)
Cardboard, corner protectors, plate protectors	Paper/paperboard	68%	5%	20%
Lumber, pallets	Wood	Information Unavailable		
Plastic roll, glass beads, slip sheet	Plastic	9%	17%	68%

4.1.3 Use stage (B1)

No impacts are associated with the use stage (B1).

4.1.4 Maintenance stage (B2)

Per PCR, the cladding was modelled as being cleaned twice per year using 500ml of 1% sodium lauryl sulfate solution per 100 m2 (UL Environment, 2018).

Table 10. *Maintenance for Morin cladding panel systems*

Name	Value	Unit
Maintenance process information (cite source in report)	Per PCR	-
Maintenance cycle	60	Number/ RSL
Maintenance cycle	150	Number/ ESL
Net freshwater consumption specified by water source and fate (source: surface water; fate:100% sewer/wastewater)	0.005	m^3
Ancillary materials specified by type (sodium lauryl sulfate solution cleaner)	0.495 water, 0.00505 Sodium.L.Sulfate	kg
Energy input	N/A	N/A
Waste materials from maintenance	500 (twice a year for wall, once a year for roof)	ml
Direct emissions to ambient air, soil, water	N/A	N/A
Further assumptions for scenario development	--	-

4.1.5 Repair/Replacement/Refurbishment stage (B3 - B5)

There are no impacts associated with repair (B3) or refurbishment (B5) of the product.

Per PCR, the reference service life of the cladding is 30 years, and the estimated service life of the building is 75 years (UL Environment, 2018). The cladding is modelled as being replaced 1.5 times.

Table 11. *Replacement for Morin cladding panel systems*

Name	Value	Unit
Reference service life	30	years
Replacement cycle	1.5	(ESL/RSL)-1
Electricity	2	kWh
Diesel	126	MJ
Net freshwater consumption	N/A	N/A
Replacement of worn parts	N/A	N/A
Further assumptions for scenario development	--	-

4.1.6 Building operation stage (B6–B7)

There is no operational energy or water use associated with the use of the product and the results for these stages are zero.

4.1.7 End of Life (C1-C4, D)

Per PCR, deconstruction (C2) energy use is identical to installation. Waste is transported 100 km (62 miles) to disposal (C2). Per EPA data on (US EPA, 2020) metal construction and demolition waste, 85% of the cladding is recycled and the remainder is sent to landfill. No biogenic carbon is removed from the environment as a result of the disposal of the products after use. For steel, Worldsteel value corrected substitution is applied. For aluminum, IAI and Part A PCR guidelines for 95% recyclability is applied (UL Environment, 2022) (Worldsteel and EUROFER, 2014) . There is no recycled content associated with the products as Morin uses 100% primary steel and primary aluminum. There are no reuse and recovery opportunities for the two products.

Table 12. *End of life (C1-C4) for Morin Panel System.*

Name		Value (Steel-Al)	Unit
Assumptions for scenario development (description of deconstruction, collection, recovery, disposal method and transportation)			
Collection process (specified by type)	Collected separately	0	kg
	Collected with mixed construction waste	244.5 - 489.0	kg
Recovery (specified by type)	Reuse	0	kg
	Recycling	231 - 474	kg
	Landfill	-	kg
	Incineration	0	kg
	Incineration with energy recovery	0	kg
	Energy conversion efficiency rate	N/A	--
Disposal (landfill)	Product or material for final deposition	36.7-73.4	kg
Removals of biogenic carbon (excluding packaging)		0	kg CO_2

Table 13. *Reuse, recovery and/or recycling potentials (D), relevant scenario information.*

Name	Value	Unit
Net energy benefit from energy recovery from waste treatment declared as exported energy in C3 (R>0.6)	0	MJ
Net energy benefit from thermal energy due to treatment of waste declared as exported energy in C4 (R<0.6)	0	MJ
Net energy benefit from material flow declared in C3 for energy recovery	0	MJ
Process and conversion efficiencies	--	
Further assumptions for scenario development (e.g. further processing technologies, assumptions on correction factors);	--	

5 LCIA: Results

It shall be reiterated at this point that the reported impact categories represent impact potentials, i.e., they are approximations of environmental impacts that could occur if the emissions would (a) follow the underlying impact pathway and (b) 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, the exceeding of thresholds, safety margins, or risks.
Results are normalized to the functional unit of 100 m2 of installed cladding over 75 years.
Life cycle impact assessment and inventory results are summarized in this section. Tabulated results are followed by a contribution analysis of the cladding to provide a sense of which modules are driving environmental burden.
The products do not have any biogenic carbon emissions. Biogenic carbon emissions from packaging are reported with the results. It should be noted that packaging materials are discarded during installation phase and there is no packaging involved at the EOL, the biogenic carbon emissions are therefore grouped under module A5.
There should be no release of hazardous, harmful or dangerous substances or emissions during the installation and use of metal panel products.
Impact category indicators are calculated using the ISO 21930 characterization methods, including acidification potential, eutrophication potential, global warming potential, ozone depletion potential, and smog potential in accordance with the PCR. Biogenic carbon uptake and biomass CO_2 emissions are also included as per ISO 21930 requirements.
Impacts reported in the tables below have been calculated as weighted averages of impacts associated with the product manufactured at Bristol, CT and Fontana, CA and Deland, FL facilities with the production volume as the basis for averaging.

Table 14. *Life cycle phases included in the product system boundary.*

Production			Installation		Use stage							End-of-Life				Benefits and Loads
Raw material supply (extraction, processing, recycled material)	Transport to manufacturer	Manufacturing	Transport to building site	Installation into building	Use / application	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	Deconstruction / demolition	Transport to EOL	Waste processing for reuse, recovery or recycling	Disposal	Reuse, recovery or recycling potential
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

X = include in scope | MND = Module not declared

5.1 Aluminum Cladding Results: Weighted Average

Table 15. *Life cycle impact assessment results (production weighted average) for Morin's aluminum cladding (100m²) according to ISO 21930.*

LCIA Results for Aluminium Cladding										
Parameter	**Unit**	**A1- A3**	**A4**	**A5**	**B2**	**B4**	**C1**	**C2**	**C4**	**D**
Impact categories										
GWP(IPCC AR6)	kg CO2 eq.	4.58E+03	1.45E+01	8.10E+00	3.04E-03	2.64E+03	7.90E+00	2.49E+00	1.54E+00	-2.86E+03
ODP	kg CFC 11 eq.	1.99E-07	2.73E-14	5.71E-14	1.49E-16	2.98E-07	5.44E-14	4.69E-15	4.93E-14	-7.46E-13
AP	kg SO2 eq.	1.49E+01	3.63E-02	6.65E-02	1.64E-05	5.80E-01	6.59E-02	5.70E-03	6.70E-03	-1.47E+01
EP	kg N eq.	5.21E-01	4.00E-03	5.09E-03	1.09E-06	1.40E-01	5.04E-03	6.53E-04	3.73E-04	-4.43E-01
SFP	kg O3 eq.	2.70E+02	8.35E-01	2.30E+00	2.99E-04	5.68E+01	2.29E+00	1.31E-01	1.18E-01	-2.38E+02
ADPf	MJ	6.22E+04	2.02E+02	1.12E+02	3.48E-02	3.80E+04	1.09E+02	3.47E+01	2.29E+01	-3.73E+04
Resource Use										
RPRe	MJ	1.21E+03	7.91E+00	5.96E+00	7.33E-02	2.62E+03	5.78E+00	1.36E+00	2.20E+00	5.16E+02
RPRm	MJ	4.38E+01	0.00E+00	0.00E+00	0.00E+00	6.58E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NRPRe	MJ	6.26E+04	2.04E+02	1.15E+02	3.82E-02	3.84E+04	1.12E+02	3.49E+01	2.35E+01	-3.75E+04
NRPRm	MJ	1.30E+02	0.00E+00	0.00E+00	0.00E+00	1.95E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SM	kg	--	--	--	--	--	--	--	--	--
RSF	MJ	--	--	--	--	--	--	--	--	--
NRSF	MJ	--	--	--	--	--	--	--	--	--
RE	MJ	--	--	--	--	--	--	--	--	--
FW	m³	5.50E+00	2.84E-02	1.82E-02	2.53E-04	9.78E+00	1.78E-02	4.88E-03	3.37E-03	9.47E-01
Output Flows and Waste Categories										
HWD	kg		--	--	--		--	--	--	--
NHWD	kg	1.54E+00	0.00E+00	1.83E+00	0.00E+00	6.00E+01	0.00E+00	0.00E+00	3.66E+01	0.00E+00
HLRW	kg	1.57E-04	6.69E-07	1.29E-06	1.04E-09	9.04E-05	1.27E-06	1.15E-07	2.35E-07	-1.01E-04
ILLRW	kg	1.68E-01	5.63E-04	1.08E-03	1.33E-06	1.68E-01	1.07E-03	9.67E-05	2.06E-04	-5.84E-02
CRU	kg	--	--	--	--	--	--	--	--	--
MFR	kg	2.90E+01	0.00E+00	1.04E+01	0.00E+00	3.70E+02	0.00E+00	0.00E+00	2.07E+02	0.00E+00
MER	kg	--	--	--	--	--	--	--	--	--
EE	MJ	--	--	--	--	--	--	--	--	--
Carbon Emission and Removals										
BCEP	kg	--	--	--	--	--	--	--	--	--
CWNR	kg	--	--	--	--	--	--	--	--	--
BCRP	kg	--	--	--	--	--	--	--	--	--
BCRK	kg	5.93E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CCR	kg	--	--	--	--	--	--	--	--	--
BCEW	kg	--	--	--	--	--	--	--	--	--
BCEK	kg	0.00E+00	0.00E+00	6.10E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CCE	kg	--	--	--	--	--	--	--	--	--

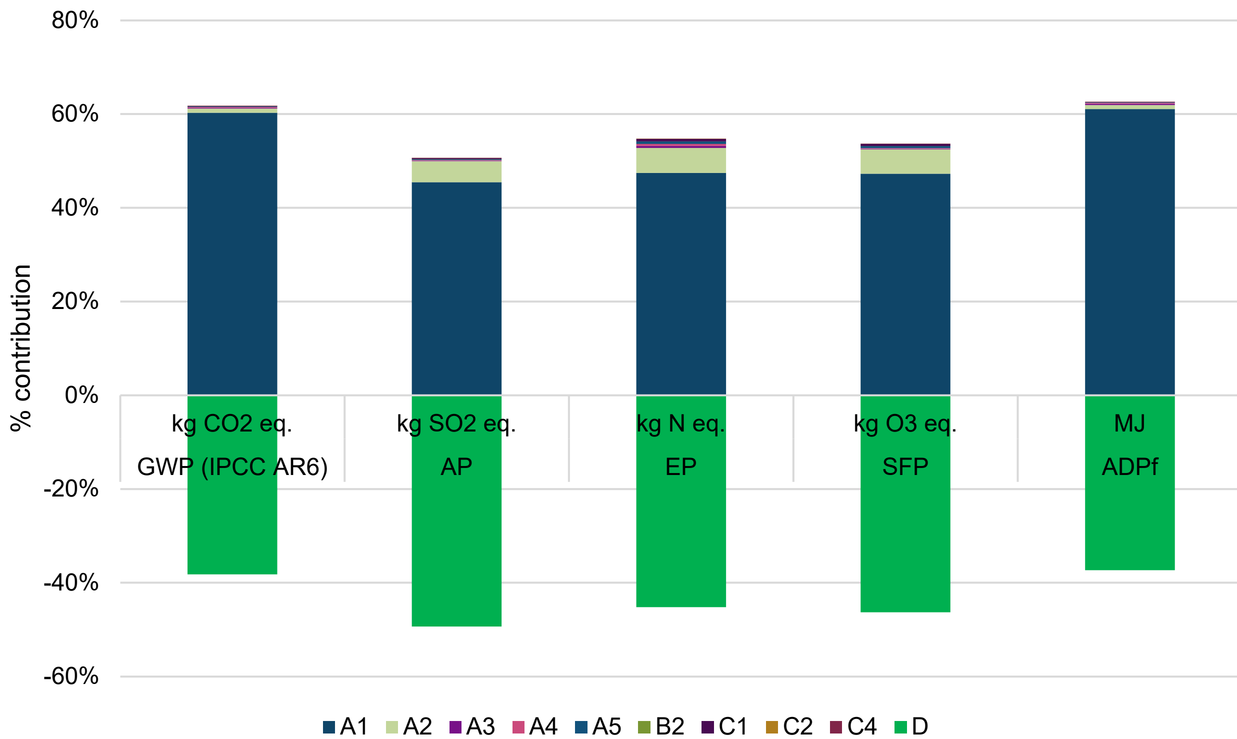


Figure 2. *Contribution Analysis for weighted average LCIA results - Aluminum Cladding (100 m² installed)*

As module B4 simply represents a 1.5x multiple of a single-product life cycle, it is omitted from the contribution analysis. The vast majority of burdens across impact categories come from raw materials production (A1), due to the high energy intensity of aluminum production. ODP is also excluded from the graph since ODP has limited relevance due to the absence of ozone-depleting emissions in the LCI, particularly in the foreground system.

5.2 Steel Cladding Results: Weighted Average

Table 16. *Life cycle impact assessment results (production weighted average) for Morin's Steel cladding (100m²) according to ISO 21930.*

LCIA Results for Steel cladding										
Parameter	**Unit**	**A1- A3**	**A4**	**A5**	**B2**	**B4**	**C1**	**C2**	**C4**	**D**
Impact categories										
GWP(IPCC AR6)	kg CO2 eq.	1.38E+03	2.91E+01	1.62E+01	6.10E-03	1.03E+03	1.58E+01	4.99E+00	3.09E+00	-7.61E+02
ODP	kg CFC 11 eq.	3.98E-07	5.48E-14	1.14E-13	2.99E-16	5.98E-07	1.09E-13	9.41E-15	9.89E-14	-2.31E-12
AP	kg SO2 eq.	2.87E+00	7.27E-02	1.33E-01	3.30E-05	2.82E+00	1.32E-01	1.14E-02	1.65E-02	-1.36E+00
EP	kg N eq.	1.75E-01	8.02E-03	1.03E-02	2.19E-06	1.63E-01	1.01E-02	1.31E-03	2.01E-03	-9.81E-02
SFP	kg O3 eq.	5.10E+01	1.67E+00	4.61E+00	6.00E-04	6.99E+01	4.58E+00	2.62E-01	2.36E-01	-1.58E+01
ADPf	MJ	1.63E+04	4.05E+02	2.24E+02	6.97E-02	1.46E+04	2.19E+02	6.95E+01	4.60E+01	-7.54E+03
Resource Use										
RPRe	MJ	1.29E+03	1.59E+01	1.19E+01	1.47E-01	2.69E+03	1.16E+01	2.72E+00	4.41E+00	4.57E+02
RPRm	MJ	1.32E+02	0.00E+00	0.00E+00	0.00E+00	1.98E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NRPRe	MJ	1.76E+04	4.08E+02	2.30E+02	7.65E-02	1.69E+04	2.24E+02	7.00E+01	4.70E+01	-7.26E+03
NRPRm	MJ	2.85E+02	0.00E+00	0.00E+00	0.00E+00	4.27E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SM	kg	--	--	--	--	--	--	--	--	--
RSF	MJ	--	--	--	--	--	--	--	--	--
NRSF	MJ	--	--	--	--	--	--	--	--	--
RE	MJ	--	--	--	--	--	--	--	--	--
FW	m³	6.30E+00	5.70E-02	3.65E-02	5.07E-04	4.70E+00	3.57E-02	9.79E-03	6.75E-03	-3.31E+00
Output Flows and Waste Categories										
HWD	kg		--	--	--		--	--	--	--
NHWD	kg	3.36E+00	0.00E+00	3.67E+00	0.00E+00	1.21E+02	0.00E+00	0.00E+00	7.34E+01	0.00E+00
HLRW	kg	5.82E-04	1.34E-06	2.59E-06	2.09E-09	8.85E-04	2.55E-06	2.30E-07	4.70E-07	8.57E-07
ILLRW	kg	4.87E-01	1.13E-03	2.17E-03	2.68E-06	7.41E-01	2.14E-03	1.94E-04	4.12E-04	8.43E-04
CRU	kg	--	--	--	--	--	--	--	--	--
MFR	kg	1.95E+01	0.00E+00	2.08E+01	0.00E+00	6.84E+02	0.00E+00	0.00E+00	4.16E+02	0.00E+00
MER	kg	--	--	--	--	--	--	--	--	--
EE	MJ	--	--	--	--	--	--	--	--	--
Carbon Emission and Removals										
BCEP	kg	--	--	--	--	--	--	--	--	--
CWNR	kg	--	--	--	--	--	--	--	--	--
BCRP	kg	--	--	--	--	--	--	--	--	--
BCRK	kg	1.30E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CCR	kg	--	--	--	--	--	--	--	--	--
BCEW	kg	--	--	--	--	--	--	--	--	--
BCEK	kg	0.00E+00	0.00E+00	1.22E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CCE	kg	--	--	--	--	--	--	--	--	--

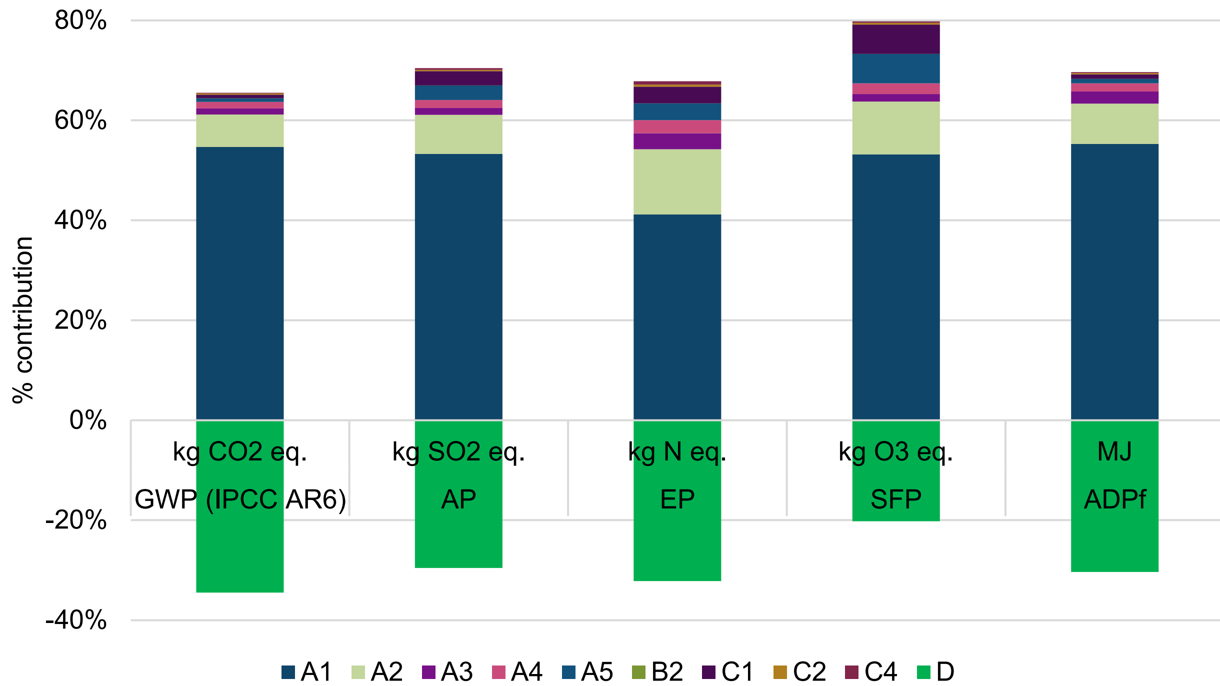


Figure 3. *Contribution Analysis for weighted average LCIA results – Steel Cladding (100m² installed)*

As module B4 simply represents a 1.5x multiple of a single-product life cycle, it is omitted from the contribution analysis. The vast majority of burdens across impact categories come from raw materials production (A1), due to the high energy intensity of steel production. However, all of those impacts except ODP and ADP_{fossil} are significantly offset by recycling credits (D). ODP is also excluded from the graph since ODP has limited relevance due to the absence of ozone-depleting emissions in the LCI, particularly in the foreground system.

Plant specific results are presented in the Annex.

6 LCA: Interpretation

The interpretation phase conforms to ISO 14040/44 standards. The interpretation included the use of evaluation and sensitivity checks to steer the iterative process during
the assessment, and a final evaluation including completeness, sensitivity, and consistency checks at the end of the study.

The results in Section 4 represent the cradle-to-grave environmental performance of 100 m² of installed Morin metal panel system cladding over a 75-year ESL. The service life for this product is 30 years, therefore 1.5 times replacement is reported in module B4.

Results for both metal cladding products show a similar pattern across the life cycle impact categories studied and key takeaways are shared between products.

Overall, the production stage (A1-A3) makes up the majority of the impact for both metal cladding products across all of the studied categories. For both aluminum and steel cladding, the production impact is driven primarily by raw materials (A1), in particular by production of the primary metal.

Aluminum cladding impacts are 4 times higher than steel cladding products, impacts could be offset if aluminum is sourced from North America instead of Bahrain.

However, approximately ~60% of the upstream impact in A1 is offset by recycling credits upon end of life (module D). This means that metal sourcing and end of life management are key areas to leverage improvements.

Transport of raw materials (A2) represents 1 - 8% of the total impact across categories for both cladding products. However, its share of impacts is more prominent impact in EP, SFP, ADPf due to fuel emissions.

Variation in GWP plant contribution is represented in the table below.

Table 17. *Plant specific GWP contribution variation in terms of overall weighted average.*

Plant	Steel Contribution	Aluminum Contribution
Bristol, CT	100%	93%
Fontana, CA	99%	98%
Deland, FL	115%	111%

From an improvement strategy perspective, it is recommended that Morin prioritizes procuring metal processed with cleaner energy/higher recycled content. Identifying new suppliers while working with lead suppliers to promote best practices can benefit Morin. Another key area of Morin pertains to end-of-life management and working with the construction industry to increase the recycling rate of metal products.

As Morin continues on its effort to reduce supply chain impacts, a recommendation is to source supplier specific metal processing data. This study is based on regional averages, but for tracking improvements and evaluating suppliers, a higher resolution of data is needed.

7 References

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8 Annex

Plant specific results: Aluminum

Table 18. *East plant Aluminum cladding results (100m² of Aluminum cladding installed).*

LCIA Results for Aluminium cladding (Bristol, CT)										
Parameter	**Unit**	**A1- A3**	**A4**	**A5**	**B2**	**B4**	**C1**	**C2**	**C4**	**D**
Impact categories										
GWP(IPCC AR6)	kg CO2 eq.	4.20E+03	1.45E+01	8.10E+00	3.04E-03	2.47E+03	7.90E+00	2.49E+00	1.54E+00	-2.59E+03
ODP	kg CFC 11 eq.	1.99E-07	2.73E-14	5.71E-14	1.49E-16	2.98E-07	5.44E-14	4.69E-15	4.93E-14	-6.76E-13
AP	kg SO2 eq.	1.37E+01	3.63E-02	6.65E-02	1.64E-05	7.61E-01	6.59E-02	5.70E-03	6.70E-03	-1.33E+01
EP	kg N eq.	4.75E-01	4.00E-03	5.09E-03	1.09E-06	1.33E-01	5.04E-03	6.53E-04	3.73E-04	-4.01E-01
SFP	kg O3 eq.	2.47E+02	8.35E-01	2.30E+00	2.99E-04	5.57E+01	2.29E+00	1.31E-01	1.18E-01	-2.15E+02
ADPf	MJ	5.70E+04	2.02E+02	1.12E+02	3.48E-02	3.54E+04	1.09E+02	3.47E+01	2.29E+01	-3.38E+04
Resource Use										
RPRe	MJ	1.10E+03	7.91E+00	5.96E+00	7.33E-02	2.39E+03	5.78E+00	1.36E+00	2.20E+00	4.68E+02
RPRm	MJ	5.50E+01	0.00E+00	0.00E+00	0.00E+00	8.25E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NRPRe	MJ	5.74E+04	2.04E+02	1.15E+02	3.82E-02	3.58E+04	1.12E+02	3.49E+01	2.35E+01	-3.40E+04
NRPRm	MJ	1.14E+02	0.00E+00	0.00E+00	0.00E+00	1.71E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SM	kg	--	--	--	--	--	--	--	--	--
RSF	MJ	--	--	--	--	--	--	--	--	--
NRSF	MJ	--	--	--	--	--	--	--	--	--
RE	MJ	--	--	--	--	--	--	--	--	--
FW	m³	5.04E+00	2.84E-02	1.82E-02	2.53E-04	8.96E+00	1.78E-02	4.88E-03	3.37E-03	8.58E-01
Output Flows and Waste Categories										
HWD	kg		--	--	--		--	--	--	--
NHWD	kg	1.35E+00	0.00E+00	1.83E+00	0.00E+00	5.97E+01	0.00E+00	0.00E+00	3.66E+01	0.00E+00
HLRW	kg	1.46E-04	6.69E-07	1.29E-06	1.04E-09	8.69E-05	1.27E-06	1.15E-07	2.35E-07	-9.13E-05
ILLRW	kg	1.55E-01	5.63E-04	1.08E-03	1.33E-06	1.58E-01	1.07E-03	9.67E-05	2.06E-04	-5.29E-02
CRU	kg	--	--	--	--	--	--	--	--	--
MFR	kg	5.94E+00	0.00E+00	1.04E+01	0.00E+00	3.36E+02	0.00E+00	0.00E+00	2.07E+02	0.00E+00
MER	kg	--	--	--	--	--	--	--	--	--
EE	MJ	--	--	--	--	--	--	--	--	--
Carbon Emission and Removals										
BCEP	kg	--	--	--	--	--	--	--	--	--
CWNR	kg	--	--	--	--	--	--	--	--	--
BCRP	kg	--	--	--	--	--	--	--	--	--
BCRK	kg	5.19E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CCR	kg	--	--	--	--	--	--	--	--	--
BCEW	kg	--	--	--	--	--	--	--	--	--
BCEK	kg	0.00E+00	0.00E+00	6.10E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CCE	kg	--	--	--	--	--	--	--	--	--

Table 19. *West plant Aluminum cladding results (100m² of Aluminum cladding installed).*

LCIA Results for Aluminium cladding (Fontana, CA)										
Parameter	**Unit**	**A1- A3**	**A4**	**A5**	**B2**	**B4**	**C1**	**C2**	**C4**	**D**
Impact categories										
GWP(IPCC AR6)	kg CO2 eq.	4.43E+03	1.45E+01	8.10E+00	3.04E-03	2.59E+03	7.90E+00	2.49E+00	1.54E+00	-2.74E+03
ODP	kg CFC 11 eq.	1.99E-07	2.73E-14	5.71E-14	1.49E-16	2.98E-07	5.44E-14	4.69E-15	4.93E-14	-7.15E-13
AP	kg SO2 eq.	1.50E+01	3.63E-02	6.65E-02	1.64E-05	1.67E+00	6.59E-02	5.70E-03	6.70E-03	-1.41E+01
EP	kg N eq.	5.23E-01	4.00E-03	5.09E-03	1.09E-06	1.71E-01	5.04E-03	6.53E-04	3.73E-04	-4.24E-01
SFP	kg O3 eq.	2.73E+02	8.35E-01	2.30E+00	2.99E-04	7.61E+01	2.29E+00	1.31E-01	1.18E-01	-2.28E+02
ADPf	MJ	6.00E+04	2.02E+02	1.12E+02	3.48E-02	3.71E+04	1.09E+02	3.47E+01	2.29E+01	-3.57E+04
Resource Use										
RPRe	MJ	1.26E+03	7.91E+00	5.96E+00	7.33E-02	2.66E+03	5.78E+00	1.36E+00	2.20E+00	4.94E+02
RPRm	MJ	9.03E+01	0.00E+00	0.00E+00	0.00E+00	1.35E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NRPRe	MJ	6.04E+04	2.04E+02	1.15E+02	3.82E-02	3.75E+04	1.12E+02	3.49E+01	2.35E+01	-3.59E+04
NRPRm	MJ	1.87E+02	0.00E+00	0.00E+00	0.00E+00	2.81E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SM	kg	--	--	--	--	--	--	--	--	--
RSF	MJ	--	--	--	--	--	--	--	--	--
NRSF	MJ	--	--	--	--	--	--	--	--	--
RE	MJ	--	--	--	--	--	--	--	--	--
FW	m³	5.32E+00	2.84E-02	1.82E-02	2.53E-04	9.45E+00	1.78E-02	4.88E-03	3.37E-03	9.06E-01
Output Flows and Waste Categories										
HWD	kg		--	--	--		--	--	--	--
NHWD	kg	2.21E+00	0.00E+00	1.83E+00	0.00E+00	6.10E+01	0.00E+00	0.00E+00	3.66E+01	0.00E+00
HLRW	kg	1.53E-04	6.69E-07	1.29E-06	1.04E-09	9.03E-05	1.27E-06	1.15E-07	2.35E-07	-9.64E-05
ILLRW	kg	1.63E-01	5.63E-04	1.08E-03	1.33E-06	1.65E-01	1.07E-03	9.67E-05	2.06E-04	-5.59E-02
CRU	kg	--	--	--	--	--	--	--	--	--
MFR	kg	1.86E+01	0.00E+00	1.04E+01	0.00E+00	3.54E+02	0.00E+00	0.00E+00	2.07E+02	0.00E+00
MER	kg	--	--	--	--	--	--	--	--	--
EE	MJ	--	--	--	--	--	--	--	--	--
Carbon Emission and Removals										
BCEP	kg	--	--	--	--	--	--	--	--	--
CWNR	kg	--	--	--	--	--	--	--	--	--
BCRP	kg	--	--	--	--	--	--	--	--	--
BCRK	kg	8.53E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CCR	kg	--	--	--	--	--	--	--	--	--
BCEW	kg	--	--	--	--	--	--	--	--	--
BCEK	kg	0.00E+00	0.00E+00	6.10E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CCE	kg	--	--	--	--	--	--	--	--	--

Table 20. *South plant Aluminum cladding results (100m² of Aluminum cladding installed).*

LCIA Results for Aluminium cladding (Deland, FL)										
Parameter	**Unit**	**A1- A3**	**A4**	**A5**	**B2**	**B4**	**C1**	**C2**	**C4**	**D**
Impact categories										
GWP(IPCC AR6)	kg CO2 eq.	5.20E+03	1.45E+01	8.10E+00	3.04E-03	2.92E+03	7.90E+00	2.49E+00	1.54E+00	-3.29E+03
ODP	kg CFC 11 eq.	1.99E-07	2.73E-14	5.71E-14	1.49E-16	2.98E-07	5.44E-14	4.69E-15	4.93E-14	-8.58E-13
AP	kg SO2 eq.	1.69E+01	3.63E-02	6.65E-02	1.64E-05	1.99E-01	6.59E-02	5.70E-03	6.70E-03	-1.69E+01
EP	kg N eq.	5.93E-01	4.00E-03	5.09E-03	1.09E-06	1.48E-01	5.04E-03	6.53E-04	3.73E-04	-5.09E-01
SFP	kg O3 eq.	3.05E+02	8.35E-01	2.30E+00	2.99E-04	5.67E+01	2.29E+00	1.31E-01	1.18E-01	-2.73E+02
ADPf	MJ	7.05E+04	2.02E+02	1.12E+02	3.48E-02	4.21E+04	1.09E+02	3.47E+01	2.29E+01	-4.29E+04
Resource Use										
RPRe	MJ	1.37E+03	7.91E+00	5.96E+00	7.33E-02	2.98E+03	5.78E+00	1.36E+00	2.20E+00	5.94E+02
RPRm	MJ	2.22E+01	0.00E+00	0.00E+00	0.00E+00	3.34E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NRPRe	MJ	7.10E+04	2.04E+02	1.15E+02	3.82E-02	4.25E+04	1.12E+02	3.49E+01	2.35E+01	-4.31E+04
NRPRm	MJ	1.51E+02	0.00E+00	0.00E+00	0.00E+00	2.26E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SM	kg	--	--	--	--	--	--	--	--	--
RSF	MJ	--	--	--	--	--	--	--	--	--
NRSF	MJ	--	--	--	--	--	--	--	--	--
RE	MJ	--	--	--	--	--	--	--	--	--
FW	m³	6.23E+00	2.84E-02	1.82E-02	2.53E-04	1.11E+01	1.78E-02	4.88E-03	3.37E-03	1.09E+00
Output Flows and Waste Categories										
HWD	kg		--	--	--		--	--	--	--
NHWD	kg	1.78E+00	0.00E+00	1.83E+00	0.00E+00	6.03E+01	0.00E+00	0.00E+00	3.66E+01	0.00E+00
HLRW	kg	1.76E-04	6.69E-07	1.29E-06	1.04E-09	9.57E-05	1.27E-06	1.15E-07	2.35E-07	-1.16E-04
ILLRW	kg	1.88E-01	5.63E-04	1.08E-03	1.33E-06	1.86E-01	1.07E-03	9.67E-05	2.06E-04	-6.71E-02
CRU	kg	--	--	--	--	--	--	--	--	--
MFR	kg	6.61E+01	0.00E+00	1.04E+01	0.00E+00	4.26E+02	0.00E+00	0.00E+00	2.07E+02	0.00E+00
MER	kg	--	--	--	--	--	--	--	--	--
EE	MJ	--	--	--	--	--	--	--	--	--
Carbon Emission and Removals										
BCEP	kg	--	--	--	--	--	--	--	--	--
CWNR	kg	--	--	--	--	--	--	--	--	--
BCRP	kg	--	--	--	--	--	--	--	--	--
BCRK	kg	6.86E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CCR	kg	--	--	--	--	--	--	--	--	--
BCEW	kg	--	--	--	--	--	--	--	--	--
BCEK	kg	0.00E+00	0.00E+00	6.10E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CCE	kg	--	--	--	--	--	--	--	--	--

Plant specific results: Steel

Table 21. *East plant Steel cladding results (100m² of Steel cladding installed).*

LCIA Results for Steel cladding (Bristol, CT)										
Parameter	Unit	A1- A3	A4	A5	B2	B4	C1	C2	C4	D
Impact categories										
GWP(IPCC AR6)	kg CO2 eq.	1.36E+03	2.91E+01	1.62E+01	6.10E-03	1.02E+03	1.58E+01	4.99E+00	3.09E+00	-7.44E+02
ODP	kg CFC 11 eq.	3.98E-07	5.48E-14	1.14E-13	2.99E-16	5.98E-07	1.09E-13	9.41E-15	9.89E-14	-2.26E-12
AP	kg SO2 eq.	2.83E+00	7.27E-02	1.33E-01	3.30E-05	2.81E+00	1.32E-01	1.14E-02	1.65E-02	-1.33E+00
EP	kg N eq.	1.73E-01	8.02E-03	1.03E-02	2.19E-06	1.63E-01	1.01E-02	1.31E-03	2.01E-03	-9.60E-02
SFP	kg O3 eq.	5.05E+01	1.67E+00	4.61E+00	6.00E-04	6.96E+01	4.58E+00	2.62E-01	2.36E-01	-1.54E+01
ADPf	MJ	1.61E+04	4.05E+02	2.24E+02	6.97E-02	1.45E+04	2.19E+02	6.95E+01	4.60E+01	-7.38E+03
Resource Use										
RPRe	MJ	1.19E+03	1.59E+01	1.19E+01	1.47E-01	1.83E+03	1.16E+01	2.72E+00	4.41E+00	4.47E+02
RPRm	MJ	1.10E+02	0.00E+00	0.00E+00	0.00E+00	-9.97E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NRPRe	MJ	1.73E+04	4.08E+02	2.30E+02	7.65E-02	2.69E+04	2.24E+02	7.00E+01	4.70E+01	-7.10E+03
NRPRm	MJ	2.29E+02	0.00E+00	0.00E+00	0.00E+00	3.43E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SM	kg	--	--	--	--	--	--	--	--	--
RSF	MJ	--	--	--	--	--	--	--	--	--
NRSF	MJ	--	--	--	--	--	--	--	--	--
RE	MJ	--	--	--	--	--	--	--	--	--
FW	m³	6.17E+00	5.70E-02	3.65E-02	5.07E-04	9.40E+00	3.57E-02	9.79E-03	6.75E-03	-3.24E+00
Output Flows and Waste Categories										
HWD	kg	--	--	--	--	--	--	--	--	--
NHWD	kg	2.70E+00	0.00E+00	3.67E+00	0.00E+00	9.55E+00	0.00E+00	0.00E+00	7.34E+01	0.00E+00
HLRW	kg	5.72E-04	1.34E-06	2.59E-06	2.09E-09	6.23E-03	2.55E-06	2.30E-07	4.70E-07	8.51E-07
ILLRW	kg	4.79E-01	1.13E-03	2.17E-03	2.68E-06	7.23E-01	2.14E-03	1.94E-04	4.12E-04	8.35E-04
CRU	kg	--	--	--	--	--	--	--	--	--
MFR	kg	9.81E+00	0.00E+00	2.08E+01	0.00E+00	4.59E+01	0.00E+00	0.00E+00	4.16E+02	0.00E+00
MER	kg	--	--	--	--	--	--	--	--	--
EE	MJ	--	--	--	--	--	--	--	--	--
Carbon Emission and Removals										
BCEP	kg	--	--	--	--	--	--	--	--	--
CWNR	kg	--	--	--	--	--	--	--	--	--
BCRP	kg	--	--	--	--	--	--	--	--	--
BCRK	kg	1.04E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CCR	kg	--	--	--	--	--	--	--	--	--
BCEW	kg	--	--	--	--	--	--	--	--	--
BCEK	kg	0.00E+00	0.00E+00	1.22E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CCE	kg	--	--	--	--	--	--	--	--	--

Table 22. *West plant Steel cladding results (100m² of Steel cladding installed).*

LCIA Results for Steel cladding (Fontana, CA)										
Parameter	**Unit**	**A1- A3**	**A4**	**A5**	**B2**	**B4**	**C1**	**C2**	**C4**	**D**
Impact categories										
GWP(IPCC AR6)	kg CO2 eq.	1.39E+03	2.91E+01	1.62E+01	6.10E-03	1.01E+03	1.58E+01	4.99E+00	3.09E+00	-7.80E+02
ODP	kg CFC 11 eq.	3.98E-07	5.48E-14	1.14E-13	2.99E-16	5.98E-07	1.09E-13	9.41E-15	9.89E-14	-2.36E-12
AP	kg SO2 eq.	2.88E+00	7.27E-02	1.33E-01	3.30E-05	2.79E+00	1.32E-01	1.14E-02	1.65E-02	-1.39E+00
EP	kg N eq.	1.74E-01	8.02E-03	1.03E-02	2.19E-06	1.58E-01	1.01E-02	1.31E-03	2.01E-03	-1.01E-01
SFP	kg O3 eq.	5.09E+01	1.67E+00	4.61E+00	6.00E-04	6.91E+01	4.58E+00	2.62E-01	2.36E-01	-1.62E+01
ADPf	MJ	1.65E+04	4.05E+02	2.24E+02	6.97E-02	1.46E+04	2.19E+02	6.95E+01	4.60E+01	-7.72E+03
Resource Use										
RPRe	MJ	1.43E+03	1.59E+01	1.19E+01	1.47E-01	2.92E+03	1.16E+01	2.72E+00	4.41E+00	4.68E+02
RPRm	MJ	1.81E+02	0.00E+00	0.00E+00	0.00E+00	2.71E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NRPRe	MJ	1.77E+04	4.08E+02	2.30E+02	7.65E-02	1.69E+04	2.24E+02	7.00E+01	4.70E+01	-7.44E+03
NRPRm	MJ	3.76E+02	0.00E+00	0.00E+00	0.00E+00	5.63E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SM	kg	--	--	--	--	--	--	--	--	--
RSF	MJ	--	--	--	--	--	--	--	--	--
NRSF	MJ	--	--	--	--	--	--	--	--	--
RE	MJ	--	--	--	--	--	--	--	--	--
FW	m³	6.45E+00	5.70E-02	3.65E-02	5.07E-04	4.80E+00	3.57E-02	9.79E-03	6.75E-03	-3.40E+00
Output Flows and Waste Categories										
HWD	kg	--	--	--	--	--	--	--	--	--
NHWD	kg	4.43E+00	0.00E+00	3.67E+00	0.00E+00	1.22E+02	0.00E+00	0.00E+00	7.34E+01	0.00E+00
HLRW	kg	5.93E-04	1.34E-06	2.59E-06	2.09E-09	9.02E-04	2.55E-06	2.30E-07	4.70E-07	8.57E-07
ILLRW	kg	4.97E-01	1.13E-03	2.17E-03	2.68E-06	7.55E-01	2.14E-03	1.94E-04	4.12E-04	8.46E-04
CRU	kg	--	--	--	--	--	--	--	--	--
MFR	kg	3.08E+01	0.00E+00	2.08E+01	0.00E+00	7.01E+02	0.00E+00	0.00E+00	4.16E+02	0.00E+00
MER	kg	--	--	--	--	--	--	--	--	--
EE	MJ	--	--	--	--	--	--	--	--	--
Carbon Emission and Removals										
BCEP	kg	--	--	--	--	--	--	--	--	--
CWNR	kg	--	--	--	--	--	--	--	--	--
BCRP	kg	--	--	--	--	--	--	--	--	--
BCRK	kg	1.71E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CCR	kg	--	--	--	--	--	--	--	--	--
BCEW	kg	--	--	--	--	--	--	--	--	--
BCEK	kg	0.00E+00	0.00E+00	1.22E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CCE	kg	--	--	--	--	--	--	--	--	--

Table 23. *South plant Steel cladding results (100m² of Steel cladding installed).*

LCIA Results for Steel cladding (Deland, FL)										
Parameter	**Unit**	**A1- A3**	**A4**	**A5**	**B2**	**B4**	**C1**	**C2**	**C4**	**D**
Impact categories										
GWP(IPCC AR6)	kg CO2 eq.	1.54E+03	2.91E+01	1.62E+01	6.10E-03	1.18E+03	1.58E+01	4.99E+00	3.09E+00	-8.21E+02
ODP	kg CFC 11 eq.	3.98E-07	5.48E-14	1.14E-13	2.99E-16	5.98E-07	1.09E-13	9.41E-15	9.89E-14	-2.49E-12
AP	kg SO2 eq.	3.22E+00	7.27E-02	1.33E-01	3.30E-05	3.19E+00	1.32E-01	1.14E-02	1.65E-02	-1.46E+00
EP	kg N eq.	2.05E-01	8.02E-03	1.03E-02	2.19E-06	1.96E-01	1.01E-02	1.31E-03	2.01E-03	-1.06E-01
SFP	kg O3 eq.	5.83E+01	1.67E+00	4.61E+00	6.00E-04	7.89E+01	4.58E+00	2.62E-01	2.36E-01	-1.70E+01
ADPf	MJ	1.84E+04	4.05E+02	2.24E+02	6.97E-02	1.68E+04	2.19E+02	6.95E+01	4.60E+01	-8.13E+03
Resource Use										
RPRe	MJ	--	--	--	--	--	--	--	--	--
RPRm	MJ	3.57E+00	0.00E+00	3.67E+00	0.00E+00	1.21E+02	0.00E+00	0.00E+00	7.34E+01	0.00E+00
NRPRe	MJ	6.20E-04	1.34E-06	2.59E-06	2.09E-09	9.43E-04	2.55E-06	2.30E-07	4.70E-07	9.25E-07
NRPRm	MJ	5.20E-01	1.13E-03	2.17E-03	2.68E-06	7.90E-01	2.14E-03	1.94E-04	4.12E-04	9.10E-04
SM	kg	--	--	--	--	--	--	--	--	--
RSF	MJ	--	--	--	--	--	--	--	--	--
NRSF	MJ	--	--	--	--	--	--	--	--	--
RE	MJ	--	--	--	--	--	--	--	--	--
FW	m³	3.08E+01	0.00E+00	2.08E+01	0.00E+00	7.01E+02	0.00E+00	0.00E+00	4.16E+02	0.00E+00
Output Flows and Waste Categories										
HWD	kg	--	--	--	--	--	--	--	--	--
NHWD	kg	3.57E+00	0.00E+00	3.67E+00	0.00E+00	1.21E+02	0.00E+00	0.00E+00	7.34E+01	0.00E+00
HLRW	kg	6.20E-04	1.34E-06	2.59E-06	2.09E-09	9.43E-04	2.55E-06	2.30E-07	4.70E-07	9.25E-07
ILLRW	kg	5.20E-01	1.13E-03	2.17E-03	2.68E-06	7.90E-01	2.14E-03	1.94E-04	4.12E-04	9.10E-04
CRU	kg	--	--	--	--	--	--	--	--	--
MFR	kg	5.55E+01	0.00E+00	2.08E+01	0.00E+00	7.38E+02	0.00E+00	0.00E+00	4.16E+02	0.00E+00
MER	kg	--	--	--	--	--	--	--	--	--
EE	MJ	--	--	--	--	--	--	--	--	--
Carbon Emission and Removals										
BCEP	kg	--	--	--	--	--	--	--	--	--
CWNR	kg	--	--	--	--	--	--	--	--	--
BCRP	kg	--	--	--	--	--	--	--	--	--
BCRK	kg	1.38E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CCR	kg	--	--	--	--	--	--	--	--	--
BCEW	kg	--	--	--	--	--	--	--	--	--
BCEK	kg	0.00E+00	0.00E+00	1.22E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CCE	kg	--	--	--	--	--	--	--	--	--