Environmental Product Declaration

Insulated Metal Panels

KINGSPAN INSULATED PANELS NORTH AMERICA
INSULATED WALL & ROOF PAN

Kingspan
Insulated Panels

Kingspan Insulated Panels Nor th America,announces the first of its kind UL certified ISO compliant

E nvironmental Product Declaration (EPD).The EPD describes environmental manufacturing footprints from cradle to grave based on an ISO compliant Life Cycle Assessment (LCA).

Kingspan's LCA calculates the environmental footprint at each stage of the supply chain, manufacturing processes, product use and end of life. All the si gnificant environmenta l impacts associated with the product, including the impact on water,air, land and climate change are reported based on ISO LCA standards.

Kingspan Insulated Panel s Nor th America is part of Kingspan Group pic, the worl d's largest manufacturer of insulated meta l panels,and as such is committed to reducing the impact of its business operations, products and services

on the environment.

Foll ow our sustainability jour ney at:

www.pathtonetzero.com

CERTIFIED
ENVIRONMENTAL PRODUCT DECLARATION
UL.COM/EPD

Insulated Metal Panels

Kingspan

Kingspan Insulated Panels North America
Insulated wall & roof panel systems

According to ISO 14025

This declaration is an environmental product declaration in accordance with ISO 14025 that describes the environmental characteristics of the aforementioned product. It promotes the development of sustainable products. This is a certified declaration and all relevant environmental information is disclosed.

PROGRAM OPERATOR	UL Environment	
DECLARATION HOLDER	Kingspan	
DECLARATION NUMBER	11CA21665.101.2	
DECLARED PRODUCT	Insulated Wall & Roof Panel Systems	
REFERENCE PCR	UL Environment. "Product Category Rules for preparing an environmental product declaration (EPD) for product group: Insulated Metal Panels & Metal Composite Panels, and Metal Cladding: Roof and Wall Panels." Valid through Oct 9, 2017. Version Oct 9, 2012	
DATE OF ISSUE	August 22, 2014	
PERIOD OF VALIDITY	5 Years	
CONTENTS OF THE DECLARATION	Product definition and information about building physics Information about basic material and the material's origin Description of the product's manufacture Indication of product processing Information about the in-use conditions Life cycle assessment results Testing results and verifications	
The PCR review was conducted by:		UL Environment Review Panel Thomas P. Gloria (Chairperson) 35 Bracebridge Rd. Newton, MA 02359-1728 Email: t.gloria@industrial-ecology.com
This declaration was independently verified in accordance with ISO 14025 by Underwriters Laboratories ☐ INTERNAL X EXTERNAL		Loretta Tam, EPD VerifierUL ONLY
This life cycle assessment was independently verified in accordance with ISO 14044 and the reference PCR by:		Thomas P. Gloria, Industrial Ecology Consultants

Description of organization and product

Kingspan Insulated Panels North America is part of Kingspan Group plc, the world's largest manufacturer of insulated metal panels. It is committed to reducing the impact of its business operations, products and services on the environment. The Kingspan Group was founded in 1972 as a small family business in Ireland. It entered the North American market in 2007 and now has manufacturing, distribution and commercial operations throughout Europe, the United States, Australia, New Zealand and the Far East. The company has a commitment to reach Net Zero in its facilities by the year 2020 and is on track to be halfway there by 2015. For more details visit http://www.pathtonetzero.com/

Product Description

Insulated Metal Panels (IMPs) in their simplest form are rigid foam sandwiched between two sheets of coated metal as shown in Figure 1. The panels are molded in a variety of styles and sizes depending on application. Steel or aluminum panel facings create a vapor, air and moisture barrier and provide long-term thermal stability. The metal skins offer long-term durability and come in a multitude of colors and finishes. This EPD represents a weighted average of the range of products manufactured in North America. The products modeled are 3" Continuous Panel Line (CPL) IMPs manufactured in Modesto CA, Deland FL, Columbus OH, Langley BC, and Caledon ON, as well as 2" laminated IMPs, which are manufactured in Columbus, OH and Modesto, CA.

Note that EPDs of construction products may not be comparable if they do not comply with the applicable PCR, ISO 14025, and where relevant EN 15804.

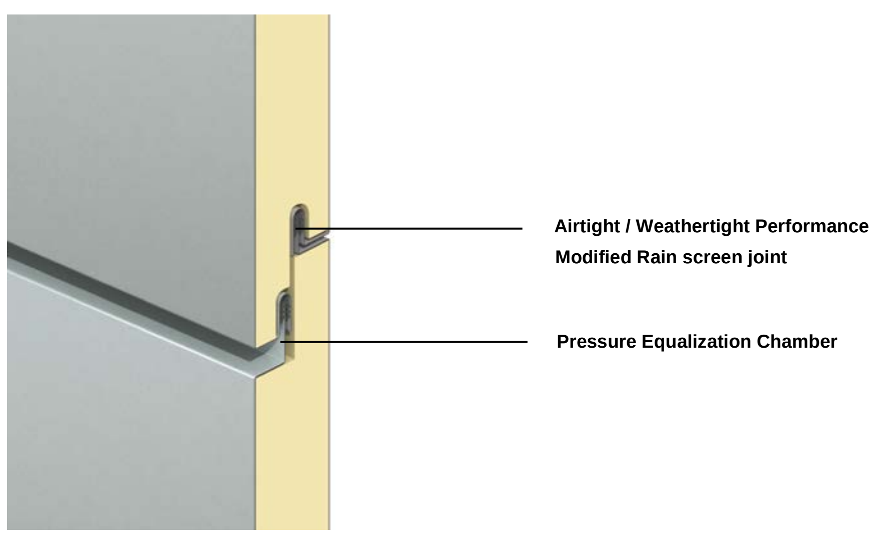

Figure 1: Benchmark Joint Graphic

Materials

Panel edges are roll formed to create interlocking side joints, which accommodate the concealed fastener and clip system and achieve the panel-to-panel seals. A variety of modules, profiles and side joints are available for insulated metal roof systems. For example, side joints can be standing seam, or overlapping as shown in Figure 2. The width of the panel is referred to as the module and can typically range from 8 inches to 45 inches. The panel thickness can vary from 2 inches to 6 inches with R-values generally ranging from 7 to 48.

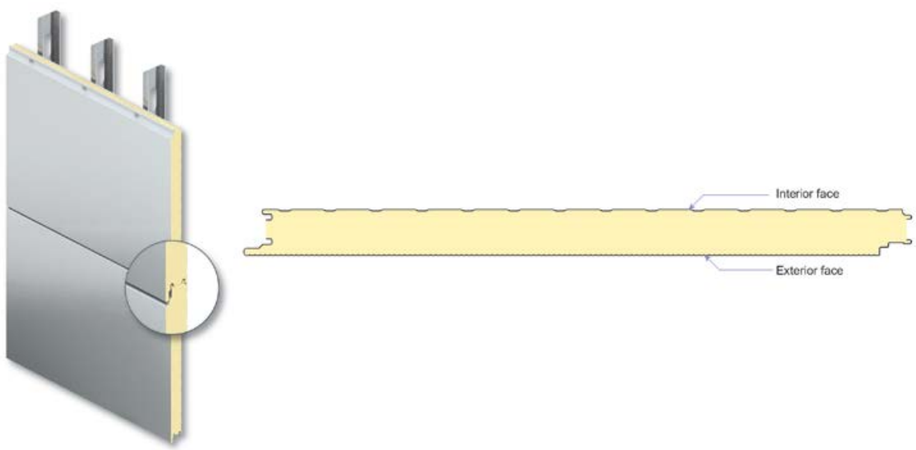

Figure 2: Profile of IMP side joints

Raw materials/primary products

Component	Material	Availability	Origin	Transport	Laminated Mass (%)	CPL Mass (%)
Galvanized Coil	Steel coil, hot-dipped galvanized	Fossil resource, limited	North America	100 mi Rail/Truck	83%	76%
Aluminum Coil	Aluminum coil	Fossil resource, limited	Europe	100 mi Rail/Truck	1%	n/a
Foamstock	MDI, Polyol, Blowing Agent, Flame Retardant, Catalyst	Fossil resource, limited	US	100 mi Rail/Truck	12%	23%

Table 1: Base material mass by percentage, Kingspan average

Auxiliary substances/Additives

In addition to the main components declared above, seam tape and a textured finish, Granitstone, are used in the manufacturing process for CPL products. Adhesive is used in both CPL and Laminated products. These auxiliaries all represent <1% of the mass of the product, except in the case of glue which represents ~4% of the weight of Laminated product.

Material Explanation

Steel coil represents steel that has been rolled out into 22, 24, or 26 gauge sheet and hot-dipped galvanized. Hot-dipped galvanized steel used by manufacturers is first coated to provide weather protection before its use in insulated metal panels. Other substrates are stainless steel, aluminum-zinc coated steel, and aluminum. To stiffen the panel faces, an embossed surface textures are commonly applied through roll forming. Profiles come in the form of light striations or planking, deep ribbing or stiffening beads. Smooth or un-embossed surfaces are also available from some manufacturers.

Aluminum coil is aluminum which has been rolled into sheets.

Polyester polyol is one of the primary components of polyurethane and is typically produced by polymerizing propylene oxide and ethylene oxide.

Methylene diphenyl diisocyanate (MDI) is another primary component of polyurethane foam.

The panel core is a polyisocyanurate or polyurethane foam. The chemistry is usually proprietary to each manufacturer. The formulation contains the additives necessary to meet the fire performance of the given product geometry and to satisfy the needs of the manufacturing process. The density is typically between 2 and 3 pcf. The panel weight will vary depending on thickness and gauge of the skins. A 2-inch panel with 26 gauge skins will weigh about 2.3 psf. The same panel with 22 gauge skins may weigh as much as 3.65 psf depending on the panel profile.

Pentane is a hydrocarbon used as a blowing agent to produce foam.

1,1,1,2-tetrafluoroethane (R-134a) is an inert hydrofluorocarbon gas also used as a blowing agent to produce foam.

Raw Material Extraction and Origin

The coated steel coil is assumed to be 100% produced in North America.

The three primary chemicals used to produce polyurethane foam—namely polyester polyol, MDI, and blowing agents—are all produced and sourced within the United States.

Availability of Raw Materials

All raw materials are produced from fossil resources and thus of limited availability. Galvanized steel coil production, however, consumes around 0.1 kg of scrap steel per kilogram of coil in the blast oxygen furnace (BOF) process.

Manufacturing

The process of manufacturing insulated metal panels requires a combination of customized mechanical equipment and foam chemistry. The most common method is the continuous process as shown in Figure 3. Greatly simplified, it entails forming the continuous metal facers while at the same time (at another point on the continuous line) injecting the foam mixture into the panel assembly. The foam then expands and fills the cavity between the metal skins as they enter a platen conveyor. Panels are then cut to length with an in-line cross cut saw. Post fabrication work can be performed on the product to treat the cut ends of the panels.

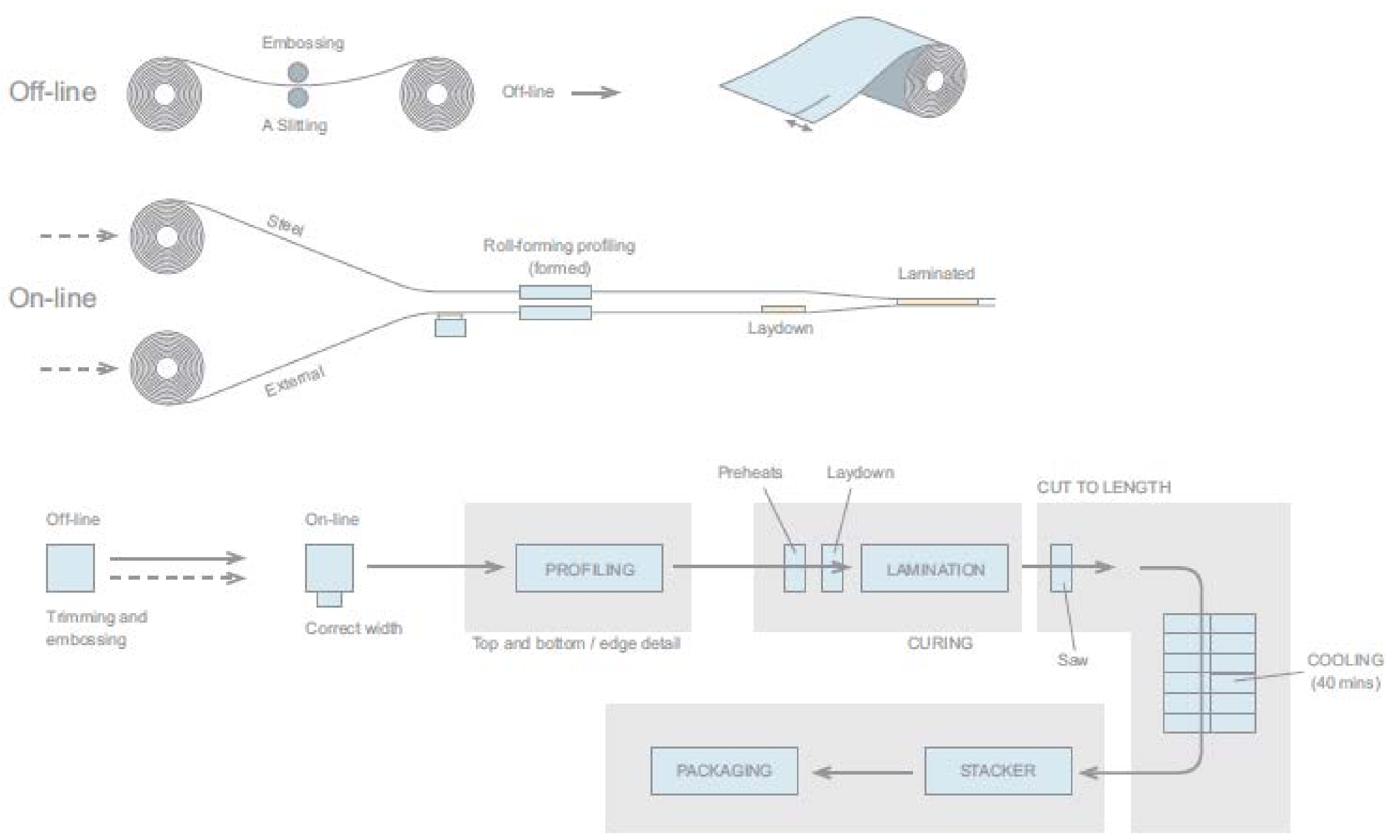

Figure 3: Schematic of continuous manufacturing process for insulated metal panels

Insulated metal panels can also be manufactured by a laminating process as shown in Figure 4. In this method, procured foam board stock in an appropriate thickness is adhered to preformed metal facers with structural adhesives and placed under pressure in a platten press operation.

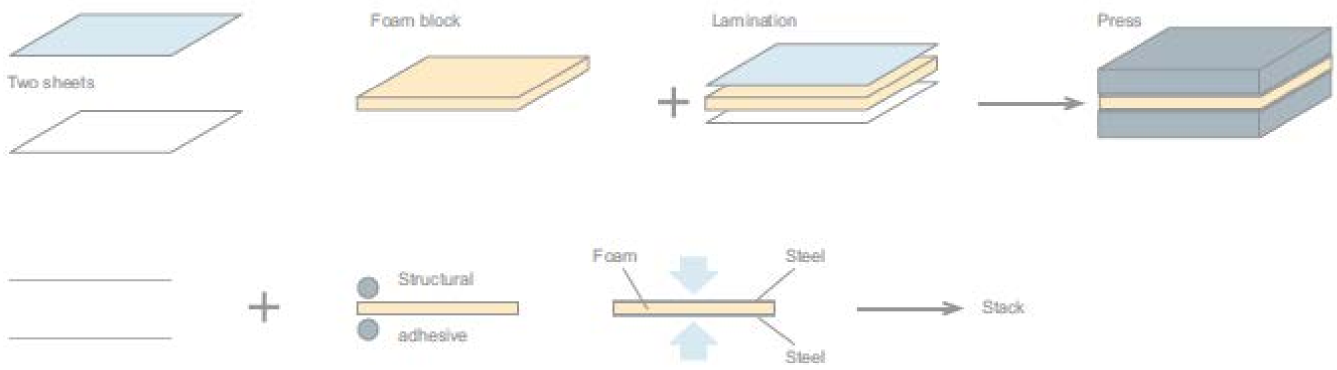

Figure 4: Schematic of laminating process for insulated metal panels

Health and Environmental Protection in Production

Kingspan has established Environmental, Health and Safety programs to ensure all federal, state, and local regulations are met or exceeded.

Range of Applications

Since the 1960s, contractors, designers and owners of commercial, industrial and refrigerated buildings have relied on insulated metal panels for excellent thermal efficiency, ease of installation and overall structural integrity. Insulated metal panels offer benefits for the entire building team. The owner achieves a thermally efficient, high performance product that has superior life cycle costs. The designer works with a product that offers many design and performance options. The erector works with a product that is easy and quick to install in almost any weather condition, in response to the common tight building schedules of today's market.

Insulated metal panels are used in a variety of applications because of their excellent performance characteristics and competitive in-place costs. Examples of buildings using IMPs:

- Aircraft hangars and service facilities
- Banks, corporate offices and municipal buildings
- Churches
- Cold-storage and food-processing plants
- Healthcare facilities
- Manufacturing facilities
- Retailers, including auto dealerships
- Schools and universities
- Sports complexes, museums and convention centers
- Warehousing and distribution centers

Insulated metal panel systems provide many of the same benefits and features found with other metal wall and roof systems as well as some unique benefits:

- Insulated metal panels are installed as a single monolithic element allowing for faster building completion in almost any kind of weather without risk to system integrity, as opposed to multiple installation steps for other insulated wall and roof systems.
- The lightweight wall and roof panels are available in a wide range of long lasting finishes and colors.
- When combined with the inherent benefits of metal facings, insulated metal panels require less maintenance than other exterior systems and meet the most demanding performance requirements.

Product Performance Data

Products contained in this EPD meet the performance requirements listed below.

Structural **-** ASTM E-72 or ASTM E330 for walls and roofs. The maximum deflection criteria for the insulated panels is typically L/180 for walls and L/240 for roofs

Thermal Transmittance **-** ASTM C-1363 at 75 degrees F mean test temperature per ASHRAE 90.1 requirements. A 40 degree F mean test temperature is commonly used for refrigerated buildings or to simulate heating of a commercial building in cold climate zones. Insulated metal panels are available with thermal resistance values generally ranging from R7 to R48.

Core Physical Properties **-** The polyurethane or polyisocyanurate core tests include:

- Density per ASTM D1622
- Shear strength per ASTM C273
- Tensile strength per ASTM D1623
- Compressive strength per ASTM D1621

The core is also tested for:

- Humidity aging per ASTM D 2126
- Heat aging per ASTM D 2126
- Cold aging per ASTM D 2126

The core properties of insulated metal panels vary slightly with the type of foam that each manufacturer uses. The most critical factor in panel production is formulating a foam system with the right balance of these properties that will ensure structural integrity and adhesion of the foam to the metal faces.

Quality Control

Kingspan's manufacturing processes utilize proven quality control systems refined through the collaborative efforts of our quality teams and our experience as the largest manufacturer of insulated panels in North America. Our Deland, Florida location is ISO 9001:2008 certified as Kingspan strives to achieve ISO 14001:2004 (Environmental Management) and ISO 9001:2008 (Quality Management) global certification for all plants.

ISO 9001 is based on number of quality management principles including a strong customer focus, the motivation and implication of top management, the process approach and continual improvement. ISO 14001 sets out the criteria for an environmental management system with a framework that a company or organization can follow to set up an effective environmental management system.

Delivery Conditions and Properties

Kingspan supplies IMPs in a variety of sizes and configurations customized to each project's requirements.

Wall panel configurations have a range as follows:

- Thickness: from 2 inches to 6 inches
- Width: from 24 inches to 42 inches
- Length: from 1 foot to 53 feet.

Joint configurations: Double tongue and groove interlocking rainscreen joint; offset double tongue and groove with extended metal shelf for positive face fastening; mechanically closed single lock standing seam at the exterior side joint with interior side joint being a single tongue-and-groove interlock.

Facings: Material:

Aluminum, Galvalume/Zincalume®, G-90 HDG steel, stucco embossed steel, aluminum and zinc

Gauge ranges:

22 to 24 gauge steel; 22, 24 and 26 gauge coated steel

Roof panel configurations:

- Thickness: 2 inches to 6 inches
- Width: 42 inches
- Length: 8 feet to 52 feet
- Joint configuration: standing seam 2 inches high minimum
- Panel facings: Galvalume, Zincalume, pre-painted steel
- Gauges 24 to 22 for exterior; 22, 24 or 26 for interior

Galvalume® is an internationally recognized trademark of BIEC International, Inc.

Packaging

Foam sheets are layered between insulated metal panels before the panels are stacked on oriented strand board (OSB) and expanded polystyrene (EPS) underlayment and wrapped in polyethylene film. This packaging represents waste codes 15 01 02 for plastic packaging and 15 01 03 for wooden packaging in the European Waste Catalogue. For the purposes of this LCA, packaging reuse is not modeled. The packaging process is outlined in Figure 5.

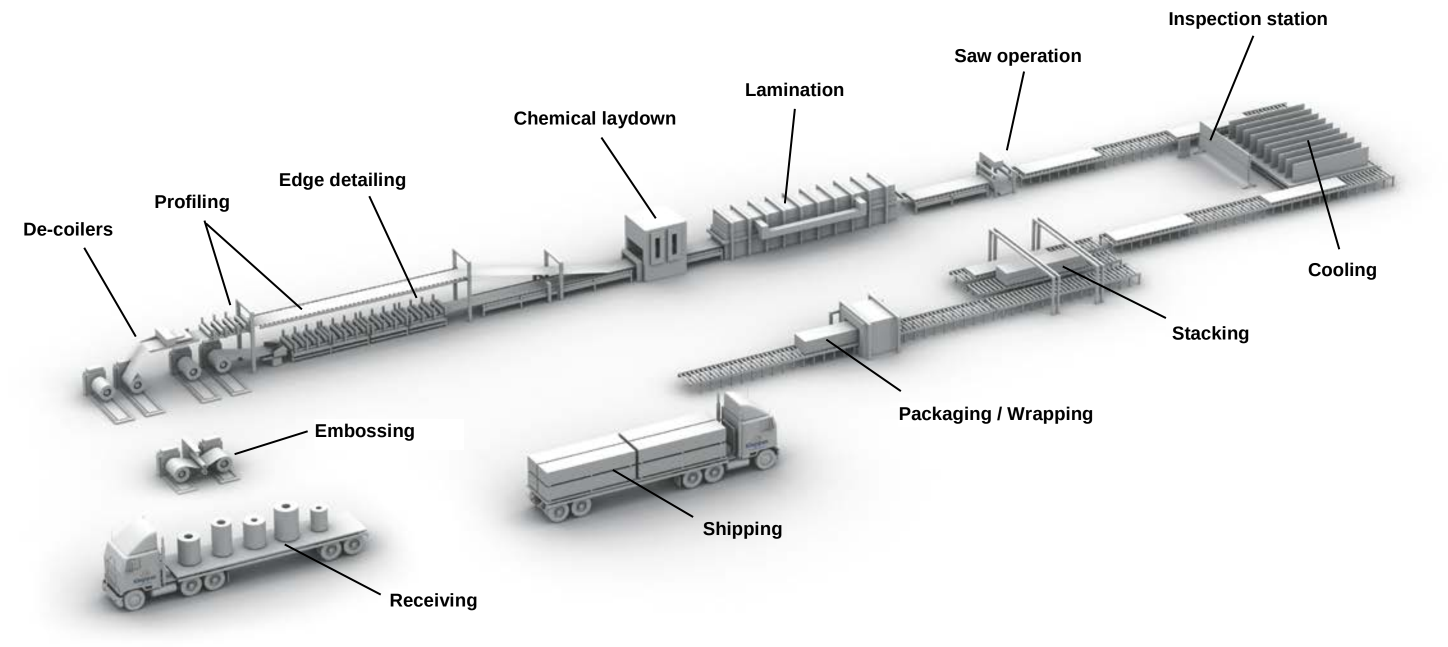

Figure 5: Schematic of packaging process for insulated metal panels

Transport to building site

Finished panels are shipped on average 100 miles to an installation site.

	Kingspan CPL	Kingspan Laminated
Transport type	Truck-trailer, basic enclosed 45,000 lb payload, class 8b	Truck-trailer, basic enclosed 45,000 lb payload, class 8b
Diesel Consumption [L/km]	0.388	0.388
Distance [km]	161	161
Volume capacity utilization factor	1	1
Capacity utilization [%]	78	78
Bulk density of transported products [kg/m^3]	51.6	55.8

Table 2: Transport to installation site

Product Installation Recommendations and Occupational Safety/Environmental Protection

The Kingspan installation guidelines demonstrate the procedures, materials, and occupational safety / environmental safety protection recommendations.

Parameter	Quantity	Units
Ancillary materials for installation (per 1000 ft2 installed);		
White butyl caulk	14.2	Kg
Steel trim, clips, & fasteners	3.32	Kg
Water use	0	Kg
Other resource use	0	MJ
Quantitative description of energy type (regional mix) and consumption during the installation process	n/a	Kg
Wastage of materials on the building site before waste processing, generated by the product's installation (scrap IMP including steel & foam)	116	Kg
Output materials as result of waste processing at the building site e.g. of collection for recycling, for energy recovery, disposal (specified by route)	0	Kg
Direct emissions to ambient air, soil and water	0	Kg

Table 3: Installation details

Use in the Building

The Kingspan panels require no regular maintenance or repair though we have modeled two repainting events over the 60 year life of the product as refurbishment.

Parameter	Quantity	Units
Refurbishment		
Refurbishment cycle	2	# per RSL
Energy input during maintenance, energy carrier type e.g. electricity, and amount, if applicable and relevant	0	kWh
Material input for refurbishment (paint)	21.53	Kg
Wastage material during maintenance (specify materials)	0	Kg

Table 4: Maintenance details

Reference Service Life

The Kingspan panels are assumed to perform for the life of a building; in this EPD the RSL is 60 years. Reference conditions are based on standard usage, as defined by ASTM and other standards listed below.

End Of Life

Though disassembly is possible, the Kingspan panels are assumed to be landfilled at the end of their life.

Singular Effects

Key Product Standards

Not all standards are applicable to all products. Consult specific manufacturer's information for standards compliance.

Material Standards

ASTM A 240	Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications*
ASTM A 653	Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process*
ASTM A 755	Standard Specification for Steel Sheet, Metallic Coated by the Hot-Dip Process and Prepainted by the Coil-Coating Process for Exterior Exposed Building Products*
ASTM A 792	Standard Specification for Steel Sheet, 55 % Aluminum-Zinc Alloy-Coated by the Hot-Dip Process*
ASTM A 924	Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process*

Performance Standards - Acoustical

ASTM E 413	Classification for Rating Sound Insulation
ASTM E 90	Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements*

Performance Standards - Air Tightness

ASTM E 1680	Standard Test Method for Rate of Air Leakage Through Exterior Metal Roof Panel Systems*
ASTM E 283	Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen*

Performance Standards - Fire

ASTM D 1929	Standard Test Method for Determining Ignition Temperature of Plastics*
ASTM E 84	Standard Test Method for Surface Burning Characteristics of Building Materials*
CAN/ULC S101	Standard Methods of Fire Endurance Tests of Building Construction Materials**
CAN/ULC S102	Standard Method of Test for Surface Burning Characteristics of Building Materials**
CAN/ULC S126	Standard Method of Test for Fire Spread Under Roof Deck Assemblies**
CAN/ULC S127	Standard Corner Wall Method of Test for Flammability Characteristics of Non-Melting Building Materials
CAN/ULC S134	Fire Test of Exterior Wall Assemblies**
CAN/ULC S138	Standard Method of Test for Fire Growth of Insulated Building Panels in a Full-Scale Room Configuration**
FM 4880	Approval Standard for Class 1 Fire Rating of Insulated Wall or Wall and Roof/Ceiling Panels, Interior Finish Materials or Coatings and Exterior Wall Systems*
NFPA 259	Standard Test Method for Potential Heat of Building Materials*
NFPA 268	Standard Test Method for Determining Ignitibility of Exterior Wall Assemblies Using a Radiant Heat Energy Source*
NFPA 285	Standard Fire Test Method for Evaluation of Fire Propagation Characteristics of Exterior Non-Load-Bearing Wall Assemblies Containing Combustible Components*
NFPA 286	Standard Methods of Fire Tests for Evaluating Contribution of Wall and Ceiling Interior Finish to Room Fire Growth*

Performance Standards - Structural

ASTM D 2126	Standard Test Method for Response of Rigid Cellular Plastics to Thermal and Humid Aging
ASTM C 273	Standard Test Method for Shear Properties of Sandwich Core Materials
ASTM D 1621	Standard Test Method for Compressive Properties Of Rigid Cellular Plastics
ASTM D 1622	Standard Test Method for Apparent Density of Rigid Cellular Plastics
ASTM D 1623	Standard Test Method for Tensile and Tensile Adhesion Properties of Rigid Cellular Plastics
ASTM D 3359	Standard Test Methods for Measuring Adhesion by Tape Test
ASTM D 6226	Standard Test Method for Open Cell Content of Rigid Cellular Plastics
ASTM E 1592	Standard Test Method for Structural Performance of Sheet Metal Roof and Siding Systems by Uniform Static Air Pressure Difference*
ASTM E 1886	Standard Test Method for Performance of Exterior Windows, Curtain Walls, Doors, and Impact Protective Systems Impacted by Missile(s) and Exposed to Cyclic Pressure Differentials
ASTM E 1996	Standard Specification for Performance of Exterior Windows, Curtain Walls, Doors, and Impact Protective Systems Impacted by Windborne Debris in Hurricanes*
ASTM E 330	Standard Test Method for Structural Performance of Exterior Windows, Doors, Skylights and Curtain Walls by Uniform Static Air Pressure Difference*
ASTM E 72	Standard Test Methods of Conducting Strength Tests of Panels for Building Construction
FM 4470	Approval Standard for Class 1 Roof Covers*
FM 4471	Approval Standard for Class 1 Panel Roofs
FM 4881	Approval Standard for Class 1 Exterior Wall Systems
UL 580	Tests for Uplift Resistance of Roof Assemblies*

Performance Standards - Thermal

ASTM C 1363	Standard Test Method for Thermal Performance of Building Materials and Envelope Assemblies by Means of a Hot Box Apparatus*
ASTM C 518	Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus*

Performance Standards - Water Resistance

AAMA 501.1	Standard Test Method for Water Penetration of Windows, Curtain Walls and Doors Using Dynamic Pressure
AAMA 501.2	Quality Assurance and Diagnostic Water Leakage Field Check of Installed Storefronts, Curtain Walls and Sloped Glazing Systems
ASTM E 1646	Standard Test Method for Water Penetration of Exterior Metal Roof Panel Systems by Uniform Static Air Pressure Difference
ASTM E 331	Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference*

Performance Standards - Weathering

ASTM B 117	Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM D 1014	Standard Practice for Conducting Exterior Exposure Tests of Paints and Coatings on Metal Substrates
ASTM D 1654	Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments
ASTM D 1729	Standard Practice for Visual Appraisal of Colors and Color Differences of Diffusely-Illuminated Opaque Materials
ASTM D 2244	Standard Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates
ASTM D 2247	Standard Practice for Testing Water Resistance of Coatings in 100% Relative Humidity
ASTM D 2794	Standard Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact)
ASTM D 4145	Standard Test Method for Coating Flexibility of Prepainted Sheet
ASTM D 4214	Standard Test Methods for Evaluating the Degree of Chalking of Exterior Paint Films
ASTM D 523	Standard Test Method for Specular Gloss
ASTM D 7091	Standard Practice for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to Ferrous Metals and Nonmagnetic, Nonconductive Coatings Applied to Non-Ferrous Metals
ASTM D 968	Standard Test Methods for Abrasion Resistance of Organic Coatings by Falling Abrasive
ASTM E 18	Standard Test Methods for Rockwell Hardness of Metallic Materials

* Referenced in IBC 2012 or IECC 2012

** Referenced in National Building Code of Canada, 2010

Thermal Effects

Thermal expansion is accommodated by a combination of thermal bow and thermal stress. Because insulated metal panels are a composite sandwich with both the interior and exterior faces bonded to the core, there is no significant differential expansion between the interior and exterior faces. The insulated panels are positively fastened to the structure and the expansion of the panel is distributed among the individual spans as thermal bow rather than linear expansion. The overall panel does not significantly elongate or contract so there is no need to install an insulated metal roof panel with slotted clips. Thermal bow does not adversely affect the performance of the panels used in a properly designed roof system since all panel analysis calculations must make allowance for it.

The ability of the insulated panel to accommodate this flexing is substantiated by Cyclic Load Tests, which subject a panel specimen to alternate cycles of positive and negative loads at a deflection limit of L/180. A typical test might use a 10-foot long panel. A cycle load of +/- 20 psf is applied.

Residual Material

Panels are offsite factory pre-cut to the customized fit of a building, which reduces waste to a minimum. Any steel which may be cut on site is recyclable.

Requirements for the Underlying Life Cycle Assessment

The LCA study and analysis were conducted according to the Product Category Rule (PCR) created by UL Environment for insulated metal panels, metal composite panels, and metal cladding, dated October 9, 2012.

Functional Unit/Reference Flow

The functional unit for this study is defined as "**coverage of 1,000 square feet with metal product**". The coverage area refers to the projected flat area covered by the product as output by the final manufacturing process step, and does not account for losses due to overlap and scrap during installation.

The reference flow necessary to meet the PCR requirements is 92.9 m^2 (1,000 sq ft) of Kingspan IMP with a total mass of 1,360 kg (3,100 lbs) for Continuous Panel Line (CPL) products and 1,470 kg (3,230 lbs) for Continuous Panel Line (CPL) products.

System Boundaries

The system boundaries are described as 'cradle-to-gate with options' since they include raw materials manufacture (A1) and transport (A2), panel manufacture (A3), transport to jobsite (A4), installation via crane (A5), use phase refurbishment (B5), transport to disposal (C2), end-of-life (C4), and credits beyond the system boundary (D) as defined in (EN 15804, 2012) and shown in Figure 6.

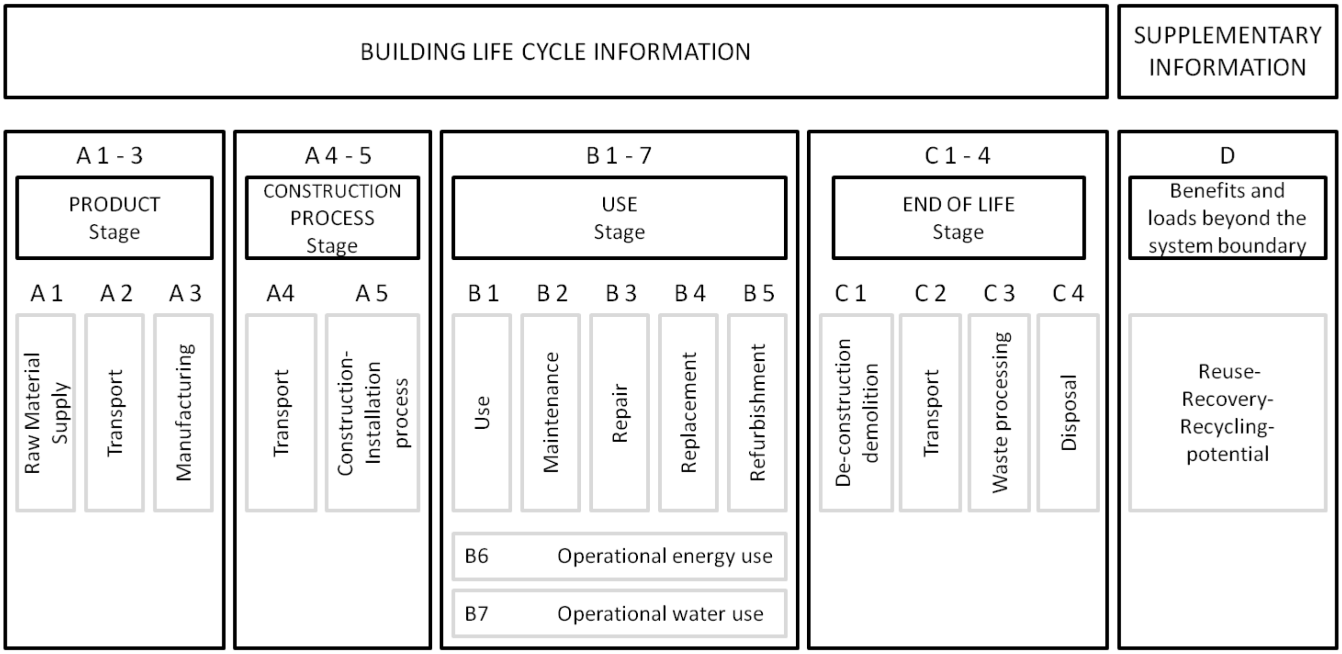

Figure 6: System Boundaries

Cut-Off Criteria

No cut-off criteria were applied in this study. All reported data was incorporated and modeled using best available LCI data.

Allocation Rules

Steel scrap generated during manufacturing is considered a valuable co-product, and was addressed with system expansion. To be consistent with the worldsteel dataset for steel coil, the scrap steel was given a credit based on the 'Value of Scrap' model as described in a study of recycling methodologies (Avery & Coleman, Sept 2009). This model is included upstream in the production of steel coil and is applied consistently to all steel used in this study.

The environmental "Value of Scrap" is applied within the product lifecycle as shown in the simplified diagram of Figure 7. In this example, the steel contains 10% scrap. Therefore, the cradle to gate production of 1 kg of steel receives the environmental burdens associated with combining 0.90 kg of primary steel with 0.10 kg of scrap steel. Upon end of life, 0.90 kg of scrap steel is produced, and therefore 0.90 kg worth of "Value of Scrap" is received. The Value of Scrap (per kg) awarded as credit during end of life is the same that adds burden to material production, but with a negative sign. In this example, the 0.90 kg of scrap first provides the 0.10 kg of scrap used during the initial manufacture, resulting in a net 0.80 kg "Value of Scrap" credit plus 0.90 kg of primary steel production. Throughout this report, however, we separate the value of scrap used during product manufacture from that potentially available at end of life. This is done for two reasons: for transparency in modeling, and in recognition of the uncertainty around end of life treatment.

The value of scrap is calculated as the difference between producing a given amount of material by primary production and the same amount of material through secondary production means. Mathematically, this is represented as follows:

LCI for 1 kg of steel including end of life = $X_{PR}(1\text{-}RC)+X_{RE}(RC) – Y(RR\text{-} RC)(X_{PR}\text{-}X_{RE})$

Where: The value of scrap = Y(XPR-XRE)

XPR = LCI for primary steel production

XRE = LCI for secondary steel production

RR = Recovery Rate at end of life

RC = Recycled content in steel object

Y = Metallic Yield

Figure 7: "Value of Scrap" as applied in a life cycle

Allocation was used in creation of upstream datasets in the Gabi database, such as refinery products. Documentation for upstream data can be provided upon request or at http://documentation.gabi-software.com/.

Scope

The scoping stage considers all elements identified as contributing to the production of IMPs and then evaluated for their inclusion or exclusion from the LCA study. Table 3 summarizes the elements included and excluded from the cradle-to-gate system boundary for this study.

Included	Excluded
✓ Raw material production and shipping ✓ Primary packaging material production and shipping ✓ Auxiliary materials required for installation (sealant, gaskets, fasteners) ✓ Other building systems installed on the IMP (flashing, trim/molding, clips, framed openings) ✓ Operation of primary production equipment ✓ Primary production facility overhead lighting/heating ✓ Transport of raw materials and finished products ✓ Product Installation/Tear-out energy and materials ✓ Product Use Phase refurbishment (repainting) ✓ Product End-of-Life	× Human labor & employee commuting × Construction of capital equipment × Maintenance and operation of support equipment × Internal transportation of materials × Product Use Phase energy effects on the building

Table 5: System Boundaries Description for Cradle-to-Gate process

Temporal Scope

Primary data collected from Kingspan for their operational activities related to the two insulation products are representative for the twelve month period from October 2011 – September 2012. Additional data necessary to model base material production and energy use, etc. was adopted from the GaBi 6 software system database.

Geographic Scope

The geographical coverage for this study is as follows:

- 2-inch Laminated Panels (R-15) – manufactured in Columbus, OH & Modesto, CA;
- 3-inch CPL Panels (R-25) – manufactured in Modesto CA, Deland FL, Columbus OH, Langley BC, and Caledon ON;
- Packaging systems production – manufactured in United States;
- Use of metal insulated panels – used around the United States; and
- End of Life Disposition (panels and packaging waste) – disposed in the United States.

A study by Architectural Energy Corporation (Hedrick, 2010) evaluates the potential energy savings associated with installing Kingspan panels on the walls of different building types in different climate zones. These energy savings calculations are described further in the section Documentation of Additional Information.

As described by the Hedrick study, the Use Phase energy savings of a Kingspan panel are highly dependent on the climate zone in which the insulated building resides. Six cities are used to represent six climate zones in the US markets: Anchorage, Minneapolis, Boston, Baltimore, Los Angeles, & Orlando. To model energy savings in each of these regions, PE electricity datasets for Alaska, the US Eastern Interconnection, and the US Western Interconnection were used, respectively.

Technological Scope

Kingspan panel manufacturing involves adhering two steel layers together around a foam core. In the case of CPL products, the foam is mixed and cured between the steel sheets, bounded by seam tape on the outside edges. Laminated panels use structural adhesive to adhere formed steel sheets to pre-shaped foam block. In both cases, the foam is created by mixing volumes of two batches of chemicals, commonly referred to as A-side and B-side. “A-side” is the industry term for the isocyanate component of foam; in this case Methylene Diphenyl Diisocyanate (MDI). This study used a dataset in the GaBi database created for the American Chemistry Council by Franklin Associates, which was used in a study[1] PE recently conducted on behalf of the Polyisocyanurate Insulation Manufacturer’s Association (PIMA). Another output of that work was the creation of a US average Polyol LCI, which is used in this Kingspan study with permission of PIMA.

The “B-side” is a mixture of polyols, fire retardants, blowing agents, catalysts, and other additives that, when mixed with “A-side”, creates foam used for insulation. One important limitation of the data collected relates to the foam composition. Since Kingspan buys B-side pre-blended and the ingredients’ exact proportions are highly confidential, the study used an industry average B-side mixture from the PIMA study.

The panel is modeled with a lifespan equivalent to that of the building, in this case with a Reference Service Life (RSL) of 60 years. Since no replacements are required, the production, use, and end of life of 1,000 ft^2 meet the functional unit requirements of the PCR. During the use phase, the panels are repainted after the first 20 years and again after the 40 year mark. These two repainting events are included as Refurbishment (B5), but the product itself has a RSL of 60 years.

To model use phase energy savings, the calculations from the AEC study were incorporated into the GaBi model such that each building type and climate zone combination could be easily evaluated. This energy evaluation describes the range of effects achieved in different building type and climate zone combinations.

- Building type: Office / School / Warehouse
- ASHRAE baseline year: 90.1-2004 / 90.1-2007
- Building location: Anchorage / Minneapolis / Boston / Baltimore / LA / Orlando

[1] Life Cycle Assessment of Polyiso Insulation for the Polyisocyanurate Insulation Manufacturers Association (PIMA) – Phelan, Pavlovich, Jewell, 2011.

Life Cycle Assessment Results and Analysis

Cradle-to-gate life cycle impact assessment results are shown for both TRACI 2.0 and CML (November 2009) characterization factors. Due to the relative approach of LCA, which is based on a functional unit, these results are relative expressions only and do not predict impacts on category endpoints, the exceeding of thresholds, safety margins, or risks.

With respect to global warming potential, no credit was given for the sequestration of biogenic carbon during the growth of plants used in plant-derived packaging materials. Any carbon temporarily sequestered during the use of bio-based materials is assumed to be re-released to the atmosphere upon their decomposition. Since the life-time of plant-derived packaging materials is shorter than the 100 year time horizon of this impact category (GWP 100), biogenic carbon was excluded from the global warming potential calculations.

Total Environmental Impacts

Environmental impacts are displayed in Table 4, which include impacts from cradle to grave, excluding use.

TRACI 2.0 Impact Categories	Units	Kingspan CPL	Kingspan Laminated
Global warming potential (GWP100)	kg CO_2-eq.	6,520	6,416
Ozone depletion potential (ODP)	kg CFC11-eq.	1.37E-04	7.52E-05
Acidification potential (AP)	kg H^+ mol-eq.	1,090	1,266
Eutrophication potential (EP)	kg N-eq.	0.799	0.890
Smog formation potential (SFP)	kg O_3-eq.	354	348
CML 2001 – November 2009			
Global warming potential (GWP100)	kg CO_2-eq.	6,520	6,417
Ozone depletion potential (ODP)	kg R11-eq.	7.40E-04	6.94E-05
Acidification potential (AP)	kg SO_2-eq.	19.4	23.443
Eutrophication potential (EP)	kg PO_4^{3-}-eq.	2.01	2.111
Photochemical oxidation potential (POCP)	kg C_2H_4-eq.	2.55	3.515
Abiotic depletion potential (ADP) – elements	kg Sb-eq.	2.86E-02	0.034
Abiotic depletion potential (ADP) – fossil fuels	MJ	59,500	88510

Table 6: Total life cycle impacts of industry-average IMP, TRACI 2.0 and CML 2001 (November 2009) methods used, excluding use phase energy savings

The cradle-to-grave impacts are broken down by life cycle stage in Figure 8 and Figure 9. Raw materials dominate the entire life cycle, with steel being the largest contributor within raw materials.

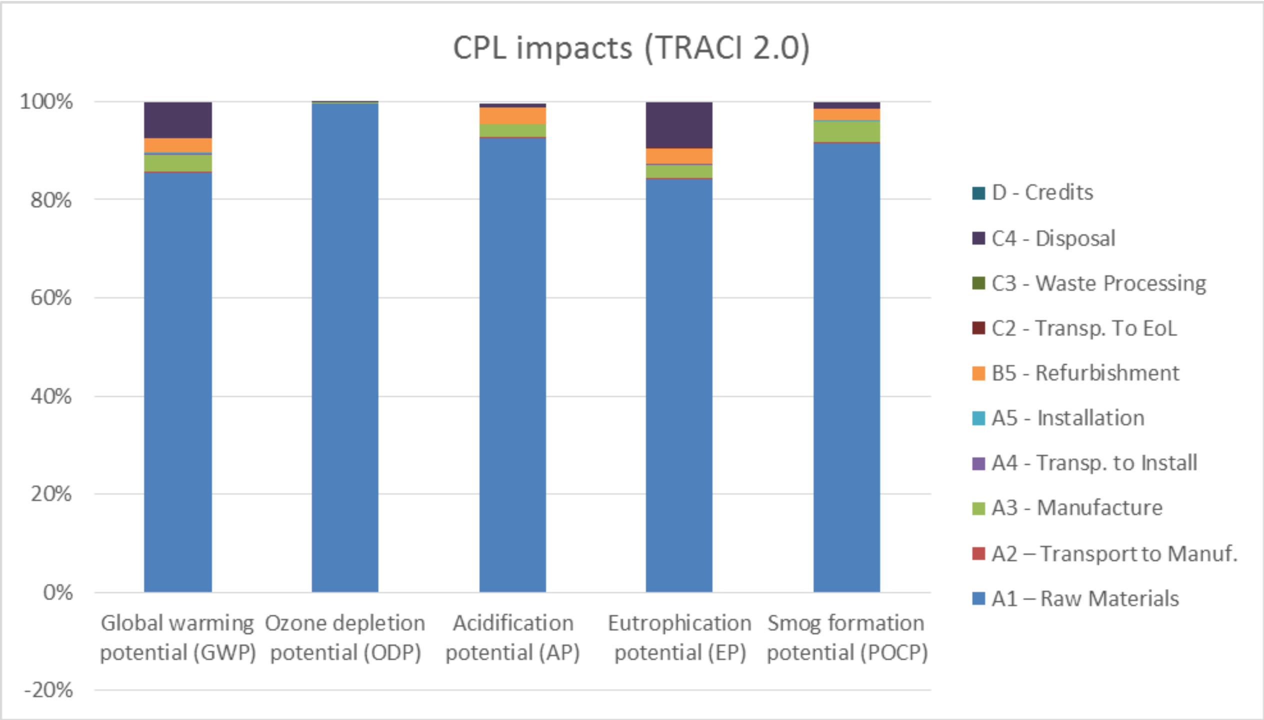

Figure 8: Total life cycle impacts of CPL IMP (TRACI 2.0 methodology)

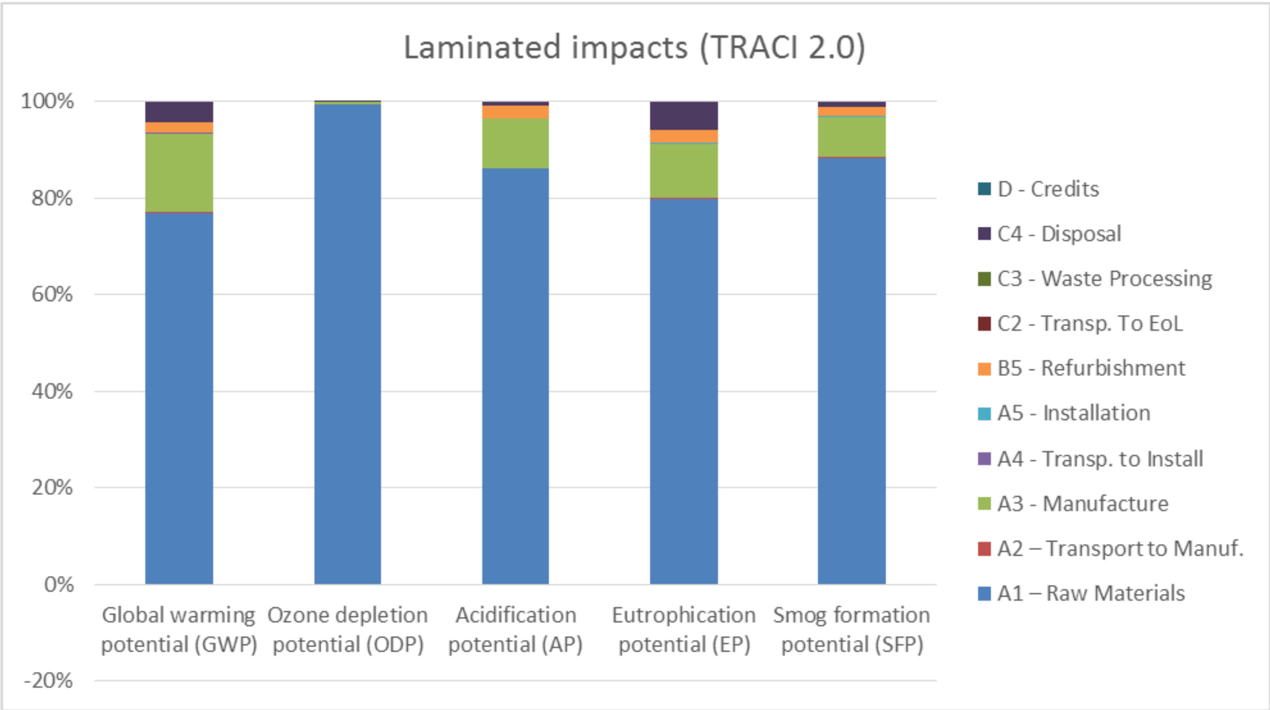

Figure 9: Total life cycle impacts of Laminated IMP (TRACI 2.0 methodology)

Energy and Material Resources

Renewable and Non-Renewable Primary Energy flows, secondary material, and water use are presented in Table 5, Figure 10, Figure 11, Figure 12, Figure 13, Figure 14, and Figure 15. Since no secondary fuels are associated with insulated metal panels, these categories are not shown.

Energy and Resource Flows	Kingspan CPL	Kingspan Laminated
Renewable primary energy, excluding those used as raw materials [MJ]	1,979	4,382
Renewable primary energy used as raw materials [MJ]	690	938
Renewable primary energy, total [MJ]	2,668	5,320
Non-Renewable primary energy, excluding those used as raw materials [MJ]	5,969	19,094
Non-renewable primary energy used as raw materials [MJ]	59,714	69,499
Primary Energy, Non-renewable [MJ]	65,682	88,593
Secondary Material [kg]	499	600
Water use [m3]	710	2686

Table 7: Energy and Resources

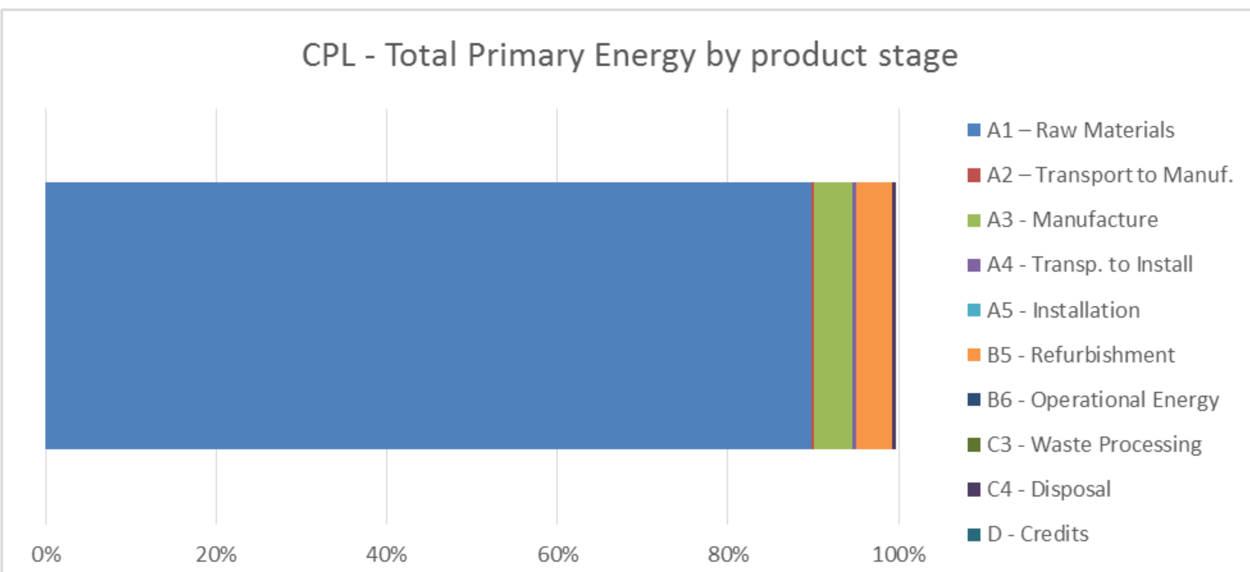

Figure 10: Total primary energy of CPL IMP by product stages

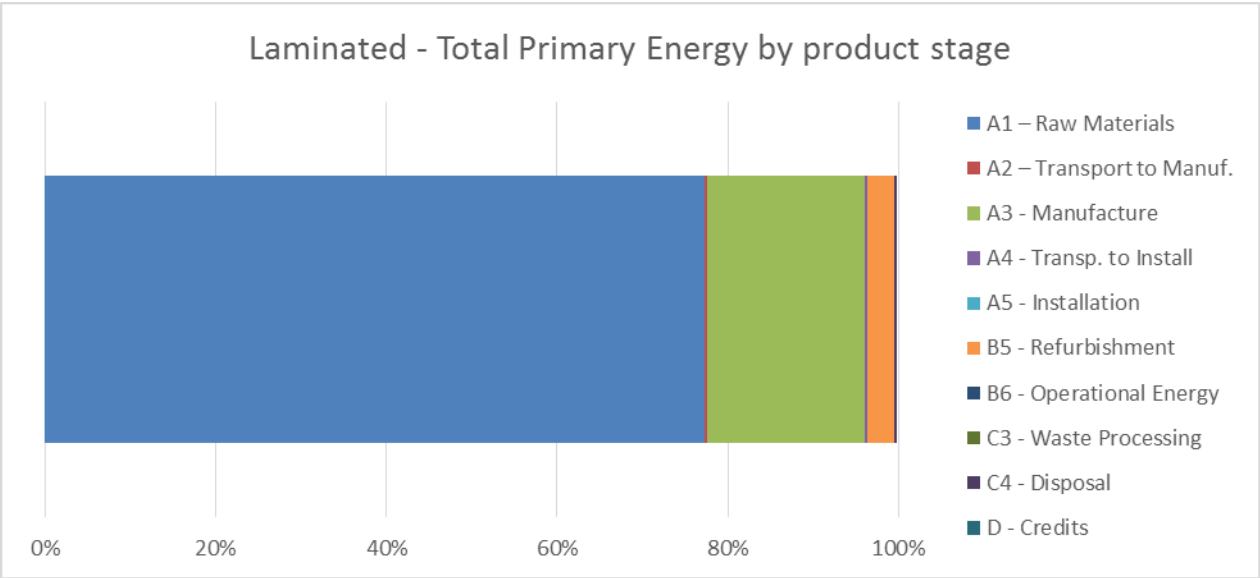

Figure 11: Total primary energy of Laminated IMP by product stages

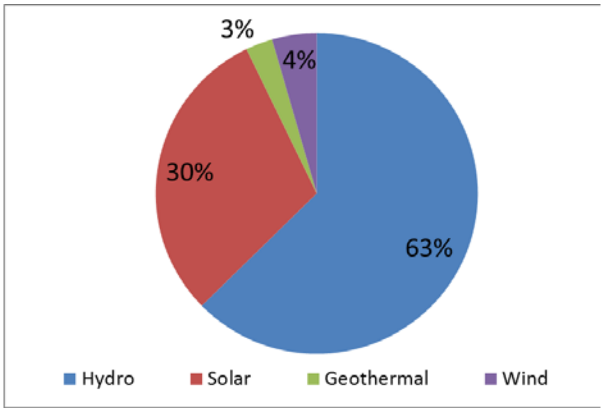

Figure 12: CPL - Renewable primary energy by source type

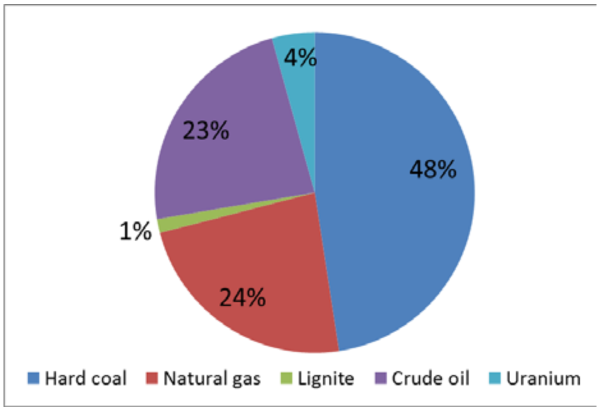

Figure 13: CPL - Non-renewable primary energy by source type

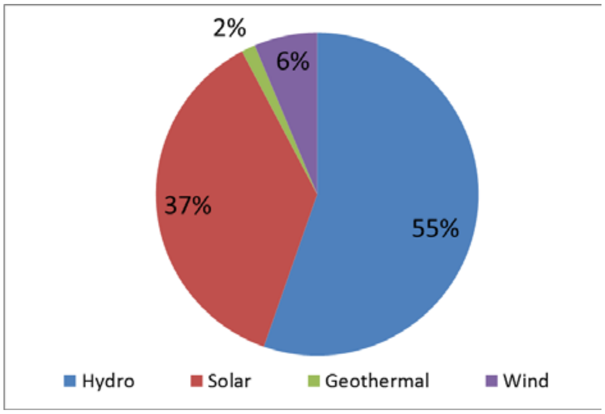

Figure 14: Laminated - Renewable primary energy by source type

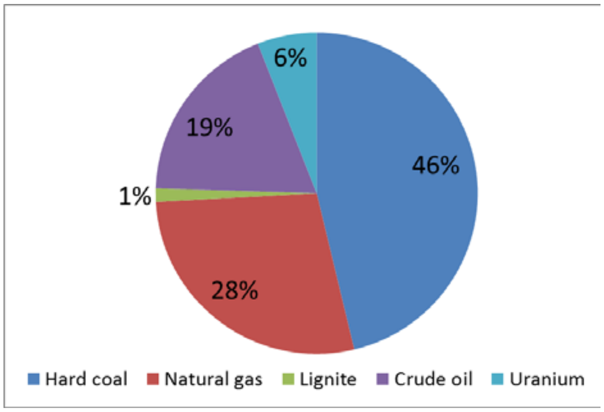

Figure 15: Laminated - Non-renewable primary energy by source type

Waste and Output Flows

Additional environmental information, including hazardous, non-hazardous, and radioactive waste disposed, materials for recycling, and materials for energy recovery are shown in Table 7.

Since no materials are sent for re-use nor recycling and no exported energy is associated with an insulated metal panel's life cycle, these categories are excluded. Additionally, all waste is assumed to be sent to landfill so no materials are available for energy recovery.

Waste and Output Flows	Kingspan CPL	Kingspan Laminated
Hazardous Waste [kg]	21	25
Non-Hazardous Waste [kg]	10	16
Radioactive Waste [kg]	1	2
Materials for Recovery [kg]	48	56

Table 8: Waste and output flows per functional unit

Interpretation

The above results represent a cradle-to-grave assessment of CPL and Laminated insulated metal panels produced by Kingspan. The study was conducted for the functional unit of coverage of 1,000 square feet with insulated metal panel products.

The global warming potential impact is dominated by stage A1 (materials) with a relevant contribution from C4 (Disposal); transportation, manufacturing, installation, and refurbishment impacts are minimal. In the raw material stage, steel coil production is the major contributor at approximately 65% of the total global warming impacts. Inputs for polyurethane foam, packaging, and other auxiliary chemical treatments contribute an additional 19% of the total global warming impacts. Disposal of the product and its packaging represent about 6% of the impacts.

With respect to the other environmental indicators, raw material dominates over 80% in all categories.

Documentation on Additional Information

To evaluate additional environmental benefits, an independent simulation analysis was performed by a third party (Architectural Energy Corporation) to evaluate the energy efficiency impact of improving typical buildings with insulated metal panel wall and roof systems, and the additional steps necessary to achieve net-zero energy buildings.

Three baseline buildings compliant with ASHRAE Standard 90.1-2004 and 90.1-2007 (school, office, and warehouse) were simulated in six locations. Each building's envelope was then improved with the insulated metal panel wall and roof systems.

The energy demand for each building type and insulation assembly are shown below in Table 7, Table 8, and Table 9. These values are a combination of kWh (for electricity) and MMBtu (for natural gas).

Energy Demand	Anchorage	Minneapolis	Boston	Baltimore	Los Angeles	Orlando
Split-Face 2004	20752.9	19325.4	13941.0	11468.8	3115.9	5585.7
Split-Face 2007	19057.9	17289.8	12543.9	10406.4	3092.4	4770.4
Kingspan 2" Panel	19100.6	16405.2	11418.9	10018.7	3216.2	4876.3
Kingspan 3" Panel	17801.6	15352.4	10740.7	9457.9	3248.5	4811.8

Table 9: Total use phase energy use - School [MMBtu]

Energy Demand	Anchorage	Minneapolis	Boston	Baltimore	Los Angeles	Orlando
Split-Face 2004	3544.6	3480.8	3106.9	3001.0	2401.2	2720.4
Split-Face 2007	3449.9	3370.8	3020.8	2904.5	2389.7	2601.9
Kingspan 2" Panel	3389.1	3291.2	2943.9	2835.9	2388.2	2596.3
Kingspan 3" Panel	3273.9	3911.5	2867.3	2768.5	2373.1	2578.4

Table 10: Total use phase energy use - Office [MMBtu]

Energy Demand	Anchorage	Minneapolis	Boston	Baltimore	Los Angeles	Orlando
Split-Face 2004	14654.6	13318.4	10946.8	10068.2	6596.9	7761.4
Split-Face 2007	14288.6	13042.4	10729.6	9876.2	6536.6	7725.0
Kingspan 2" Panel	10959.8	10335.6	8488.9	8156.8	6408.3	7719.2
Kingspan 3" Panel	10398.1	9903.2	8158.7	7877.5	6362.7	7663.1

Table 11: Total use phase energy use - Warehouse [MMBtu]

During 3rd party independent review of the Hedrick energy modeling study, Return On Investment (ROI) was requested to make the study more useful to owners and design teams. Kingspan commissioned a 3rd party first cost study and from that costing base designed a Smartphone app that demonstrates Energy Cost Savings, GHG (Green House Gas) reduction, ROI, and LEED points. This is a free download at www.pathtonetzero.com. The purpose of the app is to help design teams and owners better understand optimized envelope first energy efficiency strategies. The AEC white paper is available at: http://www.kingspanpanels.us/resourcelibrary/literature/default.aspx

Path to Net Zero

The website www.pathtonetzero.com and the related App were developed as tools to help design teams understand the importance of thermal performance to optimize a building's envelope. For full details on energy cost savings and ROI, download the free App.

Energy Reductions

Since the release of their 2010 EPD, Kingspan has achieved a 19% overall energy use reduction as part of the US Department of Energy / Energy Efficiency Renewable Energy Better Plants program and Kingspan's global commitment to NET Zero Energy for all operations by 2020. Also, Kingspan's Langley plant in British Columbia is purchasing methane gas from the landfill through Green Power Purchasing.

References

AVERY & COLEMAN 2009	Avery, C., & Coleman, C. (Sept 2009). Life Cycle Assessment Methodologies for Quantifying the Benefits of Steel Reuse and Recycling.
BARE 2010	Bare, J: TRACI 2.0: the Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts 2.0. Clean Technology Environmental Policy, 2010.
CML 2001	Guinée et al. "An operational guide to the ISO-standards (Centre for Milieukunde (CML), Leiden 2001." Center for Environmental Sciences (CML) at the University of Leiden, The Netherlands . Last Updated 2009.
EN 15804	European Committee for Standardization (CEN). "EN15804:2012. Sustainability of construction works – Environmental product declarations— Core rules for the product category of construction products"
GaBi Databases 2011	PE International Inc. "GaBi Databases 2011". November 2011. Documentation available at http://database-documentation.gabi-software.com/support/gabi/
HEDRICK 2010	HEDRICK, R. (2010). NET-ZERO ENERGY BUILDINGS USING WALL AND ROOF INSULATED METAL PANEL ENVELOPES. ARCHITECTURAL ENERGY CORPORATION.
ISO 14040	INTERNATIONAL STANDARD ORGANIZATION. ISO 14040:2006-10, ENVIRONMENTAL MANAGEMENT – LIFE CYCLE ASSESSMENT – PRINCIPLES AND FRAMEWORK (ISO 14040:2006)." GERMAN AND ENGLISH VERSION EN ISO 14040:2006 GENEVA. 2006
ISO 14044	INTERNATIONAL STANDARD ORGANIZATION. "ISO 14044:200610, ENVIRONMENTAL MANAGEMENT – LIFE CYCLE ASSESSMENT – REQUIREMENTS AND GUIDELINES (ISO 14044:2006)." GERMAN AND ENGLISH VERSION EN ISO 14044:2006 GENEVA. 2006
TRACI 2.0	BARE, J. "TRACI 2.0: THE TOOL FOR THE REDUCTION AND ASSESSMENT OF CHEMICAL AND OTHER ENVIRONMENTAL IMPACTS 2.0." CLEAN TECHNOLOGIES AND ENVIRONMENTAL POLICY. VOLUME 13, NUMBER 5, 687-696. 2011.
UL ENVIRONMENT	UL ENVIRONMENT. "PRODUCT CATEGORY RULES FOR PREPARING AN ENVIRONMENTAL PRODUCT DECLARATION (EPD) FOR PRODUCT GROUP: INSULATED METAL PANELS & METAL COMPOSITE PANELS, AND METAL CLADDING: ROOF AND WALL PANELS." VALID THROUGH OCT 9, 2017. VERSION OCT 9, 2012.

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