

**Product Category Rules for North American Gypsum Boards
FPInnovations – Gypsum PCR-2013: v1**

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NAICS Code 327420**

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1 General Information

The intended application of this product category rules (PCR) document is to provide a common set of specific rules, requirements and guidelines for developing ISO 14025 conformance Type III environmental product declarations (EPDs) for North American (NA) produced gypsum board products and to specify the underlying requirements of the Life cycle assessment (LCA) in conformance with The International Organization for Standardization (ISO) 14040 series of LCA standards.

The primary users of this PCR will be the Gypsum Association (GA) and its member companies. Other NA gypsum board manufacturers could use this PCR as well.

This PCR is valid for NA produced gypsum boards as defined in ASTM International (ASTM) Standard C11 that fulfill all standards, regulations and technical specifications shown under Section 3 Referenced documents.

This PCR complies with the requirements and follows the recommendations set within the following ISO standards:

- ISO 14025:2006, Environmental labeling and declarations - Type III environmental declarations- Principles and procedures
- ISO 21930:2007, Sustainability in building construction - Environmental declaration of building products
- ISO 14044:2006, Environmental Management - Life Cycle Assessment- Requirements and Guidelines
- ISO 14040:2006, Environmental Management - Life Cycle Assessment- Principles and Framework

In compliance with ISO 14025, Clause 6.7.1, this PCR is based on the German Institute for Construction and Environment (IBU) PCR Part A Calculation Rules for the LCA and Requirements on the Background Report (Sept 2011) and Part B Requirements on the EPD for Plasterboard (Oct 2012) modified for NA circumstances as described in Section 7. These two documents were developed in accordance with European Standard EN 15804¹. EN 15804 is a noted guidance reference in the text of this PCR.

This PCR covers three types of gypsum board EPDs: “cradle to shipping gate”, “cradle to building- option 1, 2 and 3” and “cradle to grave” as described in Section 10.

¹ EN 15804:2012 Sustainability of construction works - Environmental product declarations - Core rules for the product category of construction products.

2 Scope of the PCR

The scope of this PCR is limited to the environmental performance of NA produced gypsum boards. It does not address either the economic or social aspects of the product.

The technical content of this gypsum board PCR includes the following:

- Definition of the gypsum board product category as per ASTM C11;
- Identification of the predetermined product and technical data including environmental and health information that are to be included in a gypsum board EPD;
- Determination of the types of gypsum board EPDs and their primary audiences;
- Identification of the stages of the gypsum board's life cycle to be considered within each type of EPD and which processes are to be included within each life cycle stage; and
- Specification of the rules for calculating the Life cycle inventory (LCI) and Life cycle impact assessment (LCIA) underlying the gypsum board EPD, including data quality requirements.

Declarations based on this PCR are not comparative assertions; that is, no claim of environmental superiority can be inferred or implied. A general EPD requirement is that all information provided in the EPD, whether mandatory or voluntary, shall be verifiable.

The comparison of the environmental performance of construction products using the EPD information shall be based on the product's use and its impact on the building and shall consider the complete life cycle (all information modules).

3 Referenced documents

General Standards for Gypsum Board Products

Manufacturing and Product Standards

ASTM C11-13, Standard Terminology Relating to Gypsum and Related Building Materials and Systems

ASTM C22/C22M-00(2010), Standard Specification for Gypsum

ASTM C1396/C1396M-13, Standard Specification for Gypsum Board

CAN/CSA–A82.27-M:1991, Gypsum Board

Installation Stage

ASTM C840-11, Standard Specification for Application and Finishing of Gypsum Board

ASTM C841-03(2008), Standard Specification for Installation of Interior Lathing and Furring

ASTM C844-04(2010), Standard Specification for Application of Gypsum Base to Receive Gypsum Veneer Plaster

ASTM C1280-13, Standard Specification for Application of Exterior Gypsum Panel Products for Use as Sheathing

GA-216-2013, Application and Finishing of Gypsum Panel Products

GA-253-2012, Application of Gypsum Sheathing

CSA A82.31-M:1991, Gypsum Board Application

Additional Specifications

ASTM C473-12, Standard Test Methods for Physical Testing of Gypsum Panel Products

ASTM C1629/C1629M-11, Standard Classification for Abuse-Resistant Non decorated Interior Gypsum Panel Products and Fiber-Reinforced Cement Panels

ASTM D3273-12, Standard Test Method for Resistance to Growth of Mold on the Surface of Interior Coatings in an Environmental Chamber

ASTM E84-13a, Standard Test Method for Surface Burning Characteristics of Building Materials

ASTM E96/E96M-12, Standard Test Methods for Water Vapor Transmission of Materials

ASTM E2129-10, Standard Practice for Data Collection for Sustainability Assessment of Building Products.

ISO Conformance LCA Report of North American Gypsum Board Products

Gypsum Association LCA Final report:2011, A Cradle-to-Gate Life Cycle Assessment of ½” Regular and 5/8” Type X Gypsum Wallboards

General and Building Sector Specific ISO Standards and others for LCA, PCR and EPDs

- ISO 14040:2006, Environmental management—Life cycle assessment—Principles and framework
- ISO 14044:2006, Environmental management—Life cycle assessment—Requirements and guidelines
- ISO 14025:2006, Environmental labels and declarations- Type III environmental declarations - Principles and procedures
- ISO 21930:2007, Sustainability in building construction- Environmental declaration of building products
- ISO 15392:2008, Sustainability in building construction- General principles
- ISO 15686-1:2011, Buildings and constructed assets- Service life planning- Part 1: General principles and framework
- ISO 15686-8:2008, Buildings and constructed assets- Service life planning Part 8: Reference service life and service life estimation
- EN 15804:2012, Sustainability of construction works- Environmental product declarations- Core rules for the product category of construction products
- ISO/DIS 14046:2013, Environmental management- Water footprint- Principles, requirements and guidelines

Federal Standards and SOPs

- 40 CFR 50 Protection of Environment - Part 50: National Primary and Secondary Ambient Air Quality Standards (U.S)
(<http://www.epa.gov/air/criteria.html>)
- Clean Air Act (CAA) Section 112(r): Accidental Release Prevention/Public Management Rule (http://www.epa.gov/oem/docs/chem/caa112_rmp_factsheet.pdf)
- CERCLA Hazardous Substances (U.S)
(<http://www.epa.gov/oem/content/hazsubs/cercsubs.htm>)
- EPCRA Section 313 Toxic Release Inventory Reporting (U.S)
(<http://www.ecy.wa.gov/epcra/section313.html>)

- U.S. Department of Labor, Occupational Safety & Health Administration (OSHA) 1910.1200 Hazard Communication Standard—Toxic and Hazardous Substances (U.S)
(http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=standards&p_id=10099)
- The Canadian National Pollutant Release Inventory (NPRI) Reporting
(<http://www.ec.gc.ca/inrp-npri/default.asp?lang=En&n=4A577BB9-1>)
- U.S EPA, ORD/NRMRL/Sustainable Technology Division, Systems Analysis Branch, SOP No. S-10637-OP-1-0- Tool for the Reduction and Assessment of Chemical and other Environmental Impacts (TRACI), Software Name and Version Number: TRACI version 2.1, USER'S MANUAL, 24 July, 2012.

4 Definitions

For the purposes of this document, the following terms and definitions apply.

- **Ancillary input** - input material or product that's used by a unit process during the life cycle of the gypsum boards, but which does not constitute part of the gypsum board [adjusted from ISO 14040 and EN 15804]
- **Average data** - data representative of a product, product group or construction service, provided by more than one supplier [EN 15804]
- **Building boards** - includes all kind of building boards prepared for trade like gypsum boards, gypsum bonded particle boards, particleboards, OSB boards, fibre boards, plywood, composite boards, decorative high pressure laminate, cement based boards, wall, ceiling and flooring boards etc [*The Norwegian EPD Foundation PCR on building boards NPCR 010*].
- **Comparative assertion** - environmental claim regarding the superiority or equivalence of one product versus a competing product that performs the same function [ISO 14044]
- **Co-product** - any of two or more products coming from the same unit process or product system [ISO 14044]
- **Declared unit** - quantity of a construction product for use as a reference unit in an EPD for an environmental declaration based on one or more information modules [EN 15804 adapted from ISO 21930]; [Examples - Mass (kg), volume (m³)]
- **Dominance analysis** – an analytical technique, in which, by means of statistical tools or other techniques such as quantitative or qualitative ranking (e.g. ABC analysis), remarkable or significant contributions are examined [ISO 14044].
- **Dummy** - term used by US LCI database that refers to “empty” LCI data sets (technosphere processes).
- **Fresh water**- water having a low concentration of dissolved solids [ISO/DIS 14046].

Note 1: Fresh water typically contains less than 1000 milligrams per litre of dissolved solids and is generally accepted as suitable for withdrawal and treatment to produce potable water.

Note 2: The concentration of total dissolved solids can vary considerably over space and/or time.

- **Functional equivalent** - quantified functional requirements and/or technical requirements for a building or an assembled system (part of works) for use as a basis for comparison [EN 15804 adapted from ISO 21931-1]
- **Functional unit** - quantified performance of a product system for use as a reference unit [ISO 14040]

- **Gypsum board** - the generic name for a family of sheet products consisting of a non-combustible core primarily of gypsum with paper facing [ASTM C11]
- **Information module** - compilation of data to be used as a basis for a Type III environmental declaration covering a unit process or a combination of unit processes that are part of the life cycle of a product [ISO 14025]
- **Integrated building technical system** - are installed technical equipment supporting operation of a building. This includes technical building system for HVAC, lighting, domestic hot water and other system for sanitation, security, fire safety, internal transport and building automation and control and IT communication [Adapted from EN 15804].
- **Life cycle assessment** - compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle [ISO 14044]
- **Life cycle inventory analysis** - phase of life cycle assessment involving the compilation and quantification of inputs and outputs for a product throughout its life cycle [ISO 14040]
- **Life cycle impact assessment** - phase of life cycle assessment aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts for a product system throughout the life cycle of the product [ISO 14040]
- **Non-renewable energy** - energy from sources which are not defined as renewable energy sources [EN 15804]
- **Non-renewable resource** - resource that exists in a finite amount that cannot be replenished on a human time scale [ISO 15804]
- **PCR review** - process whereby a third party verifies the product category rules [ISO 14025]
- **Product category**- group of construction products that can fulfill equivalent functions [ISO 21930 adapted from ISO 14025].
- **Product category rules** - set of specific rules, requirements and guidelines for developing Type III environmental declarations for one or more product categories [ISO 14025]
- **Product system** - collection of unit processes with elementary and product flows, performing one or more defined functions, and which models the life cycle of product [ISO 14040]
- **Program operator** - body or bodies that operate a Type III environmental declaration program [ISO 14025]

Note - A program operator can be a company or a group of companies, industrial sector or trade association, public authorities or agencies, or an independent scientific body or other organization.

- **Reference service life**- service life of a construction product which is known to be expected under a particular set, i.e., a reference set, of in-use conditions and which may form the basis of estimating the service life under other in-use conditions [ISO 21930]

- **Reference service life data** - Information that includes the reference service life and any qualitative or quantitative data describing the validity of the reference service life. Example- typical data describing the validity of the RSL include the description of the component for which it applies [ISO 15686-8].

- **Renewable energy** - energy from renewable non-fossil sources [EN 15804]

Examples - wind, solar, aerothermal, geothermal, hydrothermal and ocean energy, hydropower, biomass, landfill gas, sewage treatment plant gas and biogases.

- **Renewable resource** - Resource that is grown, naturally replenished or naturally cleansed, on a human time scale [ISO 21930]

Note- A renewable resource is capable of being exhausted, but may last indefinitely with proper stewardship. Examples include: trees in forests, grasses in grassland, fertile soil.

- **Secondary fuel** - fuel recovered from previous use or from waste, which substitutes primary fuels [EN 15804]

Note 1- Processes providing a secondary fuel are considered from the point where the secondary fuel enters the system from the previous system.

Note 2- Any combustible material recovered from previous use or from waste from the previous product system and used as fuel in a following system is a secondary fuel.

Note 3- Examples for primary fuels are: coal, natural gas, biomass, etc.

Note 4- Examples for secondary fuels recovered from previous use or as waste are: solvents, wood, tires, oil, and animal fats.

- **Secondary material** - material recovered from previous use or from waste, which substitutes primary materials [EN 15804]

Note 1- Secondary material is measured at the point where the secondary material enters the system from another system.

Note 2- Materials recovered from previous use or from waste from one product system and used as an input in another product system are secondary materials.

Note 3- Examples for secondary materials (to be measured at the system boundary) are recycled scrap metal, crushed concrete, glass cullet, recycled wood chips, recycled plastic.

- **Specific data** - data representative of a product, product group or construction service, provided by one supplier [EN 15804]

- **Third party** - person or body that is recognized as being independent of the parties involved, as concerns the issues in question.

Note-"Parties involved" are usually supplier ("first party") and purchaser ("second party") interests [ISO 14024]

- **Type III environmental declaration**- Environmental declaration providing quantified environmental data using predetermined parameters and, where relevant, additional environmental information [EN 15804: adapted from ISO 14025].

Note- The calculation of predetermined parameters is based on the ISO 14040 series of standards, which is made up of ISO 14040, and ISO 14044. The selection of the predetermined parameters is based on ISO 21930

- **Unit process** - the smallest element considered in the life cycle inventory analysis for which input and output data are quantified [ISO 14040]

- **Upstream, downstream process** - process(s) that either precedes (upstream) or follows (downstream) a given life cycle stage [EN 15804]

- **Water consumption** - water removed from but not returned to the same drainage basin

Note - Water consumption can be because of evaporation, transpiration, product integration or discharge into a different drainage basin or the sea. Evaporation from reservoirs can be included in water consumption [ISO/DIS 14046].

- **Waste** - substances or objects that the holder intends or is required to dispose of [ISO 14040]

5 Abbreviations

ADP	Abiotic depletion potential
AP	Acidification potential
ASTM	ASTM International (formerly, American Society for Testing and Materials)
B to B	Business-to-business
B to C	Business-to-consumer
BTU	British Thermal Unit
CFC-11	Trichlorofluoromethane
CO ₂	Carbon dioxide
CRU	Components for re-use
DU	Declared unit
e.g.	exempli gratia (Lt.) translated as “for example”
EOL	End of life (also End-of-life)
EN	European standard maintained by CEN (<u>European Committee for Standardization</u>),
EP	Eutrophication potential
EPD	Environmental product declaration
ESL	Estimated service life
FGD	Flue Gas Desulphurized (also Flue Gas Desulphurization)
FU	Functional unit
GA	Gypsum Association
GWP	Global warming potential
HHV	Higher heating value
HAVC	Heating, ventilating and air conditioning
HWD	Hazardous Waste Disposed
in	inches
IBU	German Institute for Construction and Environment
IPCC	Intergovernmental Panel on Climate Change
ISO	The International Organization for Standardization
J	Joule

kg	kilogram
km	kilometer
kWh	kilowatt-hour
LCA	Life cycle assessment
LCI	Life cycle inventory
LCIA	Life cycle impact assessment
LHV	Low Heating Value
lb	pound
m ²	square meter
m ³	cubic meter
mm	millimeter
mi	miles
MDL	Material for disposal to landfill
MER	Materials for energy recovery
MJ	Mega Joule
MND	Modules not declared
MR	Materials recycling
MSDS	Material Safety Data Sheet
N	Nitrogen
NA	North America (also North american)
NAICS	North American Industry Classification System
NHWD	Non Hazardous Waste Disposed
NRMS	Non-Renewable Material Resources
NRPE	Non-Renewable Primary Energy resources
NRPE-F	Non-Renewable Primary Energy resources, fossil
NRPE-M	Non-Renewable Primary Energy resources, used as raw materials
NRPE-N	Non-Renewable Primary Energy resources, nuclear
NRSF	Non-Renewable Secondary Fuels
NUFW	Net Use of Fresh Water
O ₃	Ozone

ODP	Depletion potential of the stratospheric ozone layer
PCR	Product category rule (also Product category rules)
POCP	Photochemical ozone creation potential
R	Thermal resistance
RMS	Renewable Material Resources
RPE	Renewable Primary Energy resources
RPE-M	Renewable Primary Energy resource, used as raw materials
RSF	Renewable Secondary Fuels
RSL	Reference service life
RWD	Radioactive Waste Disposed
sf	Square foot (also square feet)
SM	Secondary Material
SO ₂	Sulfur dioxide
TRACI	Tools for the Reduction and Assessment of Chemical and other environmental Impacts
UNCPC	United Nations Central Product Code
WMO	World Meteorological Organization

Modules are identified by terms as follows:

A1 to A3	Product stage modules
A4 to A5	Construction stage modules
B1 to B7	Use stage modules
C1 to C4	End of life stage modules

6 PCR's Period of Validity

This PCR is valid for a period of 5 years from the date of the publication.

This PCR may be revised sooner by the primary users identified in Section 1. Reasons for revision might include a need to increase the geographical scope of this PCR, add other categories of building board products or revise the content that would lead to an increase in the accuracy of the PCR document.

7 Consideration of Existing PCRs

In developing this PCR, FPIInnovations took every effort to harmonize the PCR development work with existing PCRs for gypsum boards. The PCR development process, for instance, began with a search for existing valid PCRs on this particular building product category. The following two PCR documents from the IBU were valid and considered in the development of this PCR:

- Product Category Rules for Building-Related Products and Services, from the range of Environmental Product Declarations of Institute Construction and Environment e.V. (IBU): *Part A: Calculation Rules for the Life Cycle Assessment and Requirements on the Background Report, Sep 2011*
- PCR Guidance-Texts for Building-Related Products and Services, From the range of Environmental Product Declarations of Institute Construction and Environment e.V. (IBU), *Part B: Requirements on the EPD for Plasterboard, Oct 2012.*

The IBU PCR for plasterboard was modified for NA circumstances for the following reasons:

- the IBU PCR strictly follows the EN 15804:2012 standard, developed by regulatory and policy organizations in the European Union and developed by European experts rightly reflecting the interests, practices, and supply chain aspects in the EU. The PCR development team recognized the need for developing a separate, ISO 14025 and ISO 21930 compliant PCR for gypsum boards manufactured in NA;
- the IBU PCR requires applying European category impact characterization factors. Instead, the USA Environmental Protection Agency's Tools for the Reduction and Assessment of Chemical and other environmental Impacts (TRACI) system of characterization factors shall be applied for NA gypsum board LCA reports and EPDs;
- the IBU PCR requires applying European based background LCI data sources. Instead, data sources representative of NA circumstance and conditions (e.g.,

GA primary collected LCI data modules; US LCI database, US EI database, etc.) shall be used for NA gypsum board LCA reports and EPDs;

- the IBU PCR is based on European technical requirements and reference standards which are different from NA standards. As specified in Section 3, NA reference standards and technical requirements shall be used to describe the NA gypsum board products;
- the IBU PCR documents follow a specific structure. It consists of a generic IBU PCR Part A document applicable for all building and construction products and a product specific IBU PCR Part B. This NA PCR adopts a different structure and is a standalone document;
- the IBU PCR requires applying net heat content [lower heating values (LHV)] to describe energy resource parameters. In line with applicable NA practices, the NA gypsum board PCR requires mandatory reporting of the gross heat content [higher heating values (HHV)] and optional reporting of the net heat content (LHV);
- the IBU PCR follows European regulations for hazardous and toxic materials and substances. NA regulations are different from Europe- the NA gypsum board PCR specifies hazardous and toxic materials and substances in accordance with NA regulations;
- the IBU PCR requires applying specifically the EN 15804:2012 allocation methodology. The NA gypsum board PCR specifically follows (without refinement) the ISO 14044, Clause 4.3.4 allocation procedures in general and for reuse and recycling².

Despite the above variations, to maintain a comparable level of harmonization, when developing this NA gypsum board PCR, the PCR team adopted almost all of the LCA technical aspects of the IBU PCR. This includes, but is not limited to:

- The definition of declared unit (DU),
- the modular approach,
- product system boundaries,
- life cycle stages definition and processes,
- Environmental parameters derived from LCA including parameters describing environmental impacts, parameters describing resource use and parameters describing different waste categories and output flows,

² IBU PCR comply with EN 15804, Clause 6.4.3 Allocation of input flows and output emissions. As stated in EN 15084, Clause 6.4.3.1, “*In this standard, the rules for allocation are based on the guidance given in EN ISO 14044:2006, 4.3.4. However, the basic procedures and assumptions used in EN ISO 14044 have been refined in order to reflect the goal and scope of this standard and EN 15643-2*”.

- Additional technical information for the optional “construction, use and end-of-life” life cycle stages,
- Additional environmental information during the use stage which is not covered by the LCIA,
- And, the EPD content template.

8 Definition of the product category

As defined in ASTM C11, Gypsum board is the generic name for a family of sheet products consisting of a non-combustible core primarily of gypsum with a paper facing.

This gypsum board PCR covers all *paper-faced panels* complying with the C11 definition for gypsum board for all core, dimensions and edge types, manufactured in NA and installed in residential and non-residential buildings in NA.

This PCR covers all gypsum board sub-categories³ as defined in ASTM C 1396:

- Gypsum wallboard, pre-decorated gypsum board, and laminated gypsum board
- Gypsum backing board, gypsum coreboard, and gypsum shaftliner board
- Mold-resistant gypsum board
- Water-resistant gypsum backing board
- Exterior gypsum soffit board
- Gypsum sheathing board
- Gypsum base for veneer plaster
- Gypsum lath
- Gypsum ceiling board

In NA, non-paper-faced panels (e.g., glass-mat-faced panels and panels with no facing) are not defined as gypsum boards and are excluded from the scope of this PCR. Panels or boards with a core that is not primarily of gypsum are similarly excluded from the scope of this PCR⁴.

The gypsum board products considered in this PCR are specified under the North American Industry Classification System (NAICS) as the following:

Sector 31-33—Manufacturing

327420 Gypsum Product Manufacturing⁵

³ These fall under IBU PRC Part B “gypsum plasterboards” product category; It should be noted that some North American gypsum boards have no European equivalent and vice versa.

⁴ Once the ISO 14044 conformance North American LCA, LCI and information modules of non-paper-faced panels and fiberboards are available, this PCR could be expanded or adopted for these panels and board products as per ISO 14025, Clause 6.7.1.

⁵<http://www.census.gov/eos/www/naics/>

The gypsum board products considered in this PCR are covered under UNCPC Code 3699 Gypsum board manufacturing.

9 Description of the product

The EPD shall provide a narrative description of the gypsum boards in a manner that enables the user to clearly identify the product. As defined in Section 19.2 “Content of the EPD, Products”, this description will include the following:

- Product description
- Designated application of the product
- Product data (Table 6)
- Technical data (Table 7)
- Placing on the market / Application rules
- Product formulation
- Manufacturing
- Environment and health during manufacturing
- Packaging
- Product installation
- Environment and health during use stage
- Reference service life (RSL)
- End-of-Life (EOL)
- Further information (optional)

10 Gypsum boards EPD-types and the primary audience

For purposes of creating EPDs from this PCR, three types of EPDs are defined: cradle to shipping gate, cradle to building (option 1, 2 and 3) and cradle to grave. Table 1 specifies the use of functional or declared unit (FU or DU), the life cycle stages and modules, and the primary audience per type of EPD. The minimum allowable EPD produced from this PCR is cradle to shipping gate. Life cycle stages (A to C) and information modules (A1, A2...C4) are explained in detail in Section 11.3 System boundaries.

Table 1 Gypsum board EPD types

EPD-type	FU or DU	Life Cycle Stages and modules	Primary audience
Cradle to shipping gate	DU	Product stage; modules A1 to A3	Business-to-business (B to B)
Cradle to building- (Option 1)	DU	Product and construction stages; modules A1 to A5	Business-to-business (B to B)
Cradle to building- with EOL stage (Option 2)	DU	Product, construction and EOL stages; modules A1 to A5 and C1 to C4	Business-to-business (B to B)
Cradle to building- with use stage (Option 3)	FU	Product, construction and use stages; modules A1 to A5 and B1 to B5	Business-to-business (B to B)
Cradle to grave	FU	Product, construction, use and EOL stages; modules A1 to C4	Business to business (B to B) and/or Business to consumer (B to C)

11 Requirements for the underlying LCA

EPD shall be based on an LCA, LCI and/or information modules conducted according to the guidance given in ISO 14040 and ISO 14044.

11.1 Functional and declared unit

Based on ISO 14044, a product system may fulfill a number of possible functions and the one(s) selected for a LCA study depend(s) on the goal and scope of the LCA. For example, building board products (including gypsum boards) can provide multiple functions such as covering a certain area, creating a barrier that controls noise, air, water, and thermal transmission between the external environment and the interior space of a building, as well as other functions such as load carrying capacity, thermal mass and aesthetics.

For a particular LCA, not all functions may be relevant and the relevant ones must be identified. The FU defines the quantification of the identified functions (performance characteristics) of the product, in our case gypsum board products, for use as a reference unit in an EPD.

Any comparison between different building boards and/ or gypsum boards shall be made on the basis of the same function(s) and quantified by the same FU in the form of their reference flows.

If the FU covers only one function, [e.g the average thermal resistance of the building boards (in m²K/W)] and additional functions are not taken into account, then these omissions shall be explained and documented.

For purposes of defining the FU, a NA Estimated Service Life (ESL) of building of 60 years shall be applied.

The DU is used instead of a FU when the precise function of the product or scenario(s) at the building level is not stated or is unknown [EN 15804].

A DU provides a reference by means of which the material flows of the information modules of a construction product are normalized (in a mathematical sense) to produce data, expressed on a common basis [ISO 21930, EN 15804].

The DU shall be applied when the EPD covers one or more life cycle stages as information modules, (e.g. in the instance of a “cradle to shipping gate”, “cradle to building- option 1” and “cradle to building- option 2” EPDs) but shall not be used in the cases of “cradle to building- option 3” and “cradle to grave” EPDs.

The DU is 1000 sq. ft of gypsum board product with a specified thickness in “y” inches. The conversion to 1 kg must also be declared. As required in ISO 21930, Clause 6.2.3 information provided using a DU shall not be used for purposes of comparing building board EPDs. In this instance, a FU must be defined and a “cradle to grave” LCA of building boards shall be conducted.

11.2 Reference service life

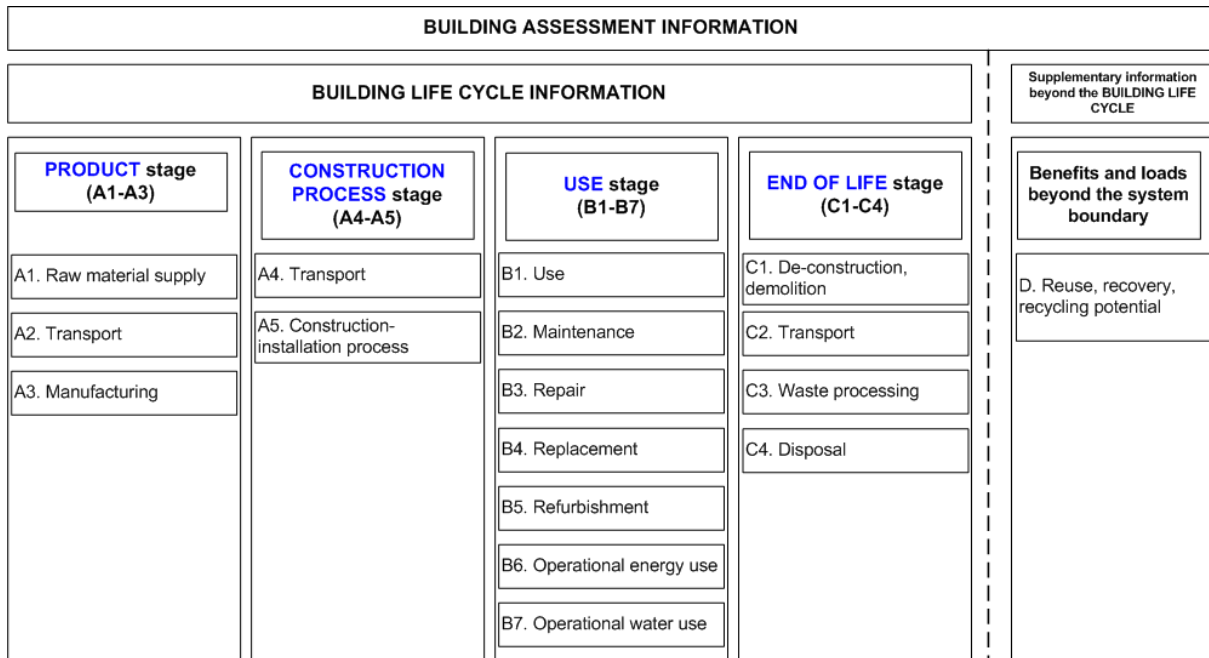
The RSL of gypsum board manufactured and installed in residential and non-residential buildings in NA is greater than or equal to 60 yrs (≥ 60).

- For “cradle to shipping gate”, “cradle to building- option 1” and “cradle to building- option 2” EPDs, the RSL shall be declared as *“Not specified”*.
- For “cradle to building- option 3” and “cradle to grave” EPDs, the RSL shall be reported as 60 years.

11.3 System boundaries

Figure 1 shows a generic illustration of the gypsum boards life cycle stages and modules in the framework of the LCA of the building.

Figure 1 Gypsum boards life cycle stages and modules [EN 15804 adapted from ISO 21930]



For the purposes of creating any type of gypsum boards **EPDs** from this PCR, the “Product” stage must be included (see Table 1).

A1-A3 Product stage

The following three modules (A1 to A3) shall be included in the “product stage”:

- A1 Raw material extraction and processing, processing of secondary material (e.g. recycling processes)
- A2 Transport to the manufacturer
- A3 Manufacturing

Specifically, the “Product stage” shall account for the following processes listed per each module (A1 to A3):

A1– Extraction and processing of raw materials, (e.g. raw gypsum quarry and mining). All unit processes depicted in Figure 2 system boundaries for quarrying and/or mining process shall be included as applicable⁶.

⁶ In instances where gypsum board manufacturers do not have access to supplier specific raw gypsum LCI data they shall use the respective rolled up average GA raw gypsum LCI data (available for three NA regions: Canada, Mexico and United States), provided by GA upon request.

A1– Reuse of products or materials from a previous product system (e.g. internally recycled gypsum waste, dust and cull).

A1– Processing of secondary materials used as input for manufacturing the product (e.g. Flue gas desulphurization (FGD) gypsum, other appropriate synthetic gypsums, and recycled gypsum from gypsum boards on-site construction off-cuts).

A1– Generation of electricity, steam and heat from primary energy resources, also including fuel extraction, refining and transport.

A1– Energy recovery and other recovery processes from secondary fuels, but not including those processes that are part of waste processing in the previous product system, if applicable.

A2 Transportation up to the factory gate (in-bound transportation) and internal transport (mobile plant support equipment).

A3 Cradle–to–gate production of ancillary inputs (e.g. dry and wet additives and packaging materials).

A3 Cradle–to–gate production of intermediate products; (e.g. gypsum facing and backing papers). All unit processes depicted in Figure 3 system boundaries for gypsum paper manufacturing shall be included as applicable⁷.

A3 Manufacturing of gypsum board products and co-products (if applicable). All unit processes depicted in Figure 4 system boundaries for the gypsum board manufacturing process shall be included as applicable.

A3 Out-bound transportation and processing of the generated waste, including any packaging waste.

A3 Wastewater out-bound transportation and treatment.

A3 Heating, ventilation, and air conditioning (HVAC), and lighting of the manufacturing facilities and operation of pollution abatement equipment;

Product stage includes provision of all input materials, products, and energy including waste disposal during the production stage. However, production of capital goods, infrastructure, office HVAC and lighting and personnel related activities are excluded.

Modules A1, A2 and A3 may be declared as one aggregated module A1-3.

For the purposes of creating gypsum boards “cradle to building– option 1, 2 and 3” and “cradle to grave” EPDs based on this PCR, the “Construction, Use and End-of-Life” stages and their respective life cycle modules (A4-A5, B1-B7 and C1- C4) are of importance (see Figure 1) and shall be included as specified in Section 10, Table 1.

⁷ In instances where gypsum board manufacturers do not have access to supplier specific gypsum paper LCI data they shall use the rolled up average GA gypsum paper LCI data (both facing and backing papers) provided by GA upon request.

Figure 2 Cradle-to-gate system boundaries of the gypsum quarry and mining process

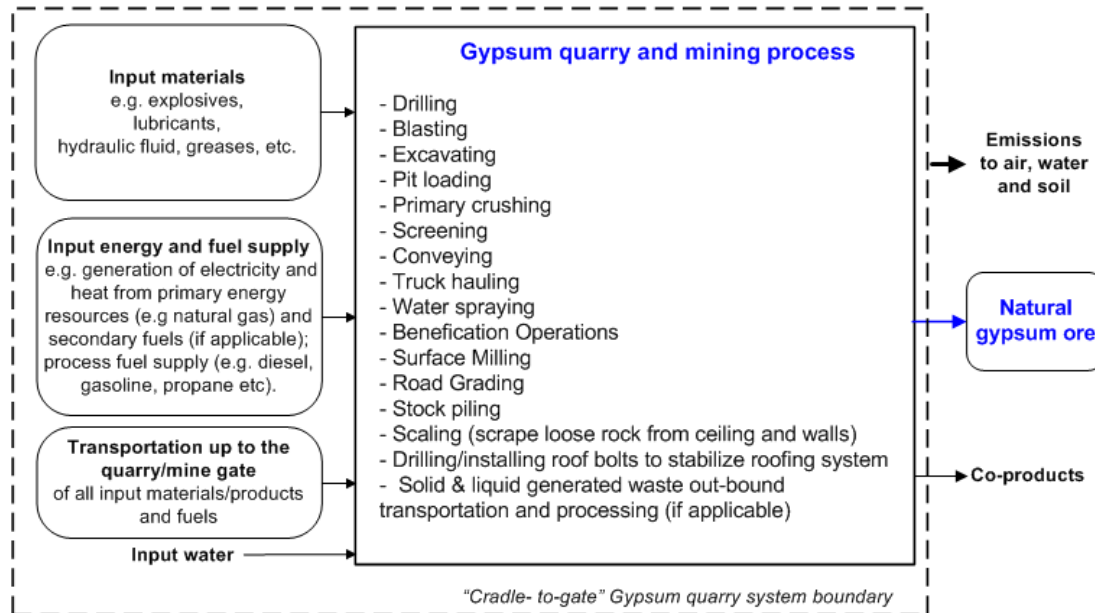


Figure 3 Cradle-to-gate system boundaries of the gypsum paper manufacturing

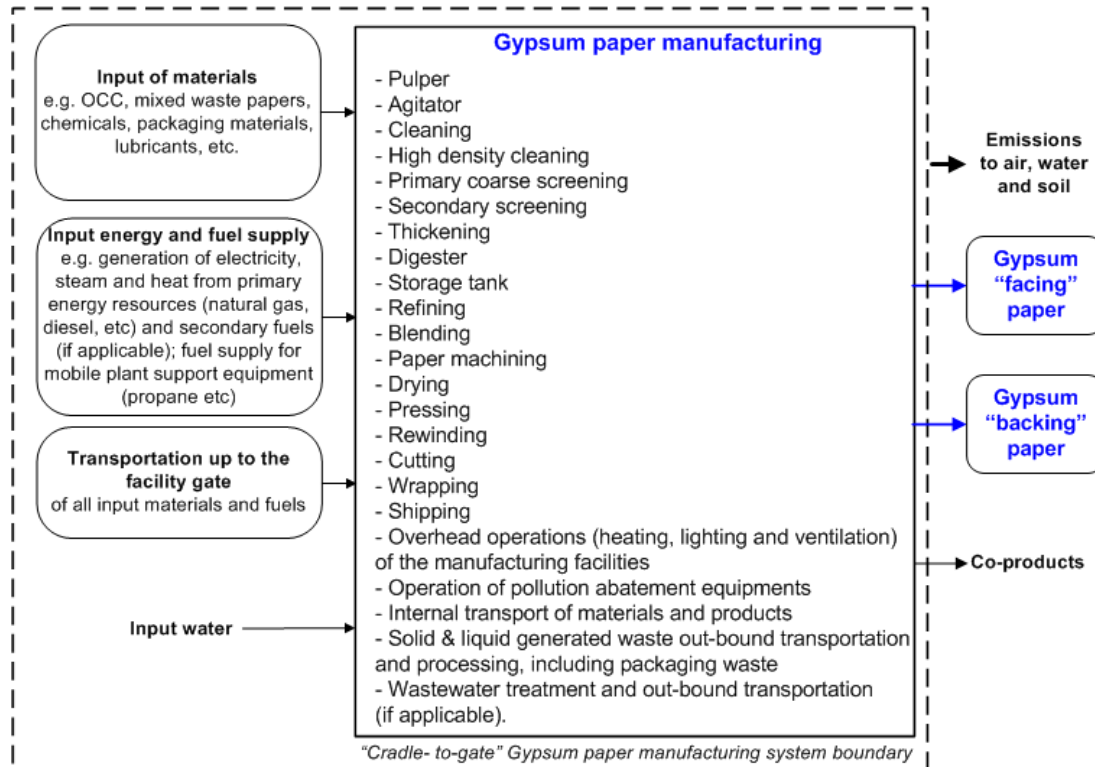
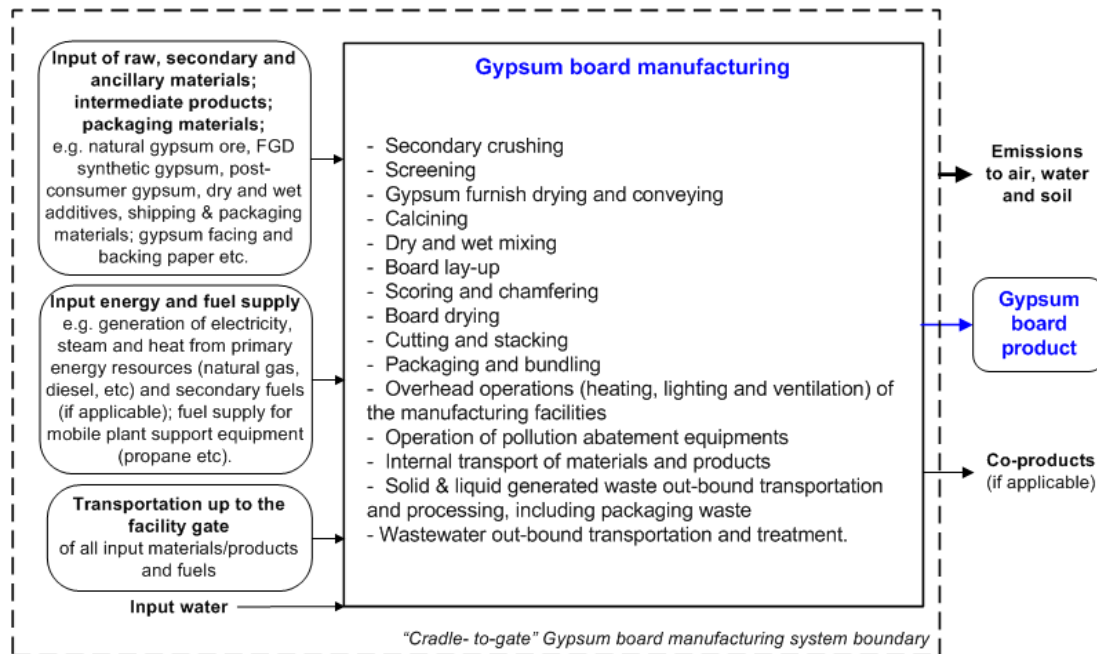


Figure 4 Cradle-to-gate system boundaries of the gypsum boards manufacturing

A4-A5 Construction stage

The construction stage shall account for the following:

- A4 Transportation from the manufacturing gate to the building site

The default average distribution mileage of gypsum boards from the manufacturing gate to the distribution gate shall be 448 km (280 miles) by commercial tractor-trailer truck and 208 km (130 miles) by rail⁸. Final transportation from the distribution gate to the construction site is defaulted to 40 km (25 miles) by a single unit truck with an empty backhaul. Any exceptions to these modes and mileages shall be justified in the LCA report and noted in the EPD.

- A4-A5 Storage of products, including the provision of heating, cooling and humidity control
- A4-A5 Wastage of construction products (additional production processes to compensate for the loss of waste products)

“The default on-site installation waste” scenario for gypsum boards shall be 10% on a surface area basis (i.e, 100 sf/ 1,000 sf or 0.10 m²/m²) of gypsum board product. Any exceptions shall be justified in the project LCA report and noted in the EPD.

- A4-A5 Waste processing (including both installation waste and packaging waste).

⁸ GA LCA Report 2011

- A5 Installation of the gypsum board into the building including manufacture and transportation of ancillary inputs and any energy or water required for installation or operation of the construction site.

The construction stage includes provision of all materials (adhesive, joint tape, joint treatment materials, and fasteners) and energy, as well as waste processing. Also included are all impacts and aspects related to any losses during this construction process stage (i.e. production, transport, and waste processing and disposal of the lost products and materials).

If available, the GA/manufacturer is required to report primary data for the A4-A5 key technical parameters. These must be clearly stated and the GA/manufacturer should have supporting documentation to justify the reported values for the purpose of validation.

B1-B5 Use stage related to the building structure

It shall be noted that “Use stage” is to be accounted for when preparing either “cradle to grave” or “cradle to building- option 3” EPDs (see Table 1). based on the FU where the selected function and technical performance of the product are defined.

Neither “cradle to shipping gate” nor “cradle to building- option 1 and 2” EPDs cover the use phase of gypsum board products and as such are based on the DU.

The use stage related to the building structure shall account for (B1 through B5). These modules and their descriptions are modified as needed in this PCR:

– B1: Use of the installed gypsum boards;

The module “use of the installed gypsum boards” shall cover any emissions to the environment not covered by B2-B7 arising from gypsum boards during their normal use in the building. Any emission (e.g. VOCs , asbestos) should be reported in conformance with the result tests (see Section 19.7 Additional environmental information).

– B2: Maintenance

The module “maintenance” covers the combination of all planned technical and associated administrative actions during the service life to maintain the product (gypsum board) installed in a building or its parts in a state in which it can perform its required function and technical performance, as well as preserve the aesthetic qualities of the product. It will include preventative and regular maintenance activity such as cleaning, planned servicing, replacement or mending of worn, damaged or degraded parts. Water and energy usage required for cleaning, as part of maintenance shall be included in this module, and not in modules B6 and B7 [EN 15804, Clause 6.3.4.4.2].

– B3: Repair

The module “repair” covers the combination of all planned technical and associated administrative actions during the service life associated with corrective, responsive or

reactive treatment of gypsum board or its parts installed in the building to return it to an acceptable condition in which it can perform its required function and technical performance. It also covers the preservation of the aesthetic qualities of the product [EN 15804, Clause 6.3.4.4.2].

Replacement of a broken component or part due to damage should be assigned to “repair”, whereas replacement of a whole product due to damage should be assigned to the module “replacement”. Replacement of a whole construction element as part of a concerted replacement program for the building should be considered as “refurbishment” [EN 15804, Clause 6.3.4.4.2].

– B4: Replacement

The module “replacement” covers the combination of all technical and associated administrative actions during the service life associated with the return of a construction product (gypsum boards) to a condition in which it can perform its required function and technical performance, by replacement of a whole construction element [EN 15804, Clause 6.3.4.4.2].

The ESL of the building in North America is defined as 60 years. RSL of the gypsum boards is specified as greater than or equal to 60 yrs. The number of replacements of the whole gypsum board products is declared null.

– B5: Refurbishment

The module “refurbishment” covers the combination of all technical and associated administrative actions during the service life of a product (gypsum boards) associated with the return of a building or their parts to a condition in which it can perform its required functions. These activities cover a concerted program of maintenance, repair and/or replacement activity, across a significant part or whole section of the building. Restoration activities should be included within refurbishment [EN 15804, Clause 6.3.4.4.2].

Use stage related to the building structure (B1 to B5) shall include provision and transport of all materials, products and related energy and water use, as well as waste processing up to the end-of-waste state or disposal of final residues during this part of the use stage. Also included are all impacts and aspects related to any losses during this part of the use stage (i.e. production, transport, and waste processing and disposal of the lost products and materials).

B1 through B5 shall be incorporated under normal conditions to achieve the specified RSL (greater than or equal to 60 yrs) and according to GA and/or manufacturers’ guidelines.

Due to a broad range of possible applications of gypsum boards, modules B2 to B5 shall be specified on a case by case basis according to the underlying LCA study supporting the EPD. If the precise function of the gypsum board products at the building

level is not stated or is unknown (FU is not defined), no general statements can be made in regard to B2 to B5.

B2 to B5 key parameters must be clearly stated (if applicable), and the GA/manufacture should have supporting documentation to justify the reported values (including “null” values) as required in section 19.4.

B6-B7 Use stage related to the operation of the building

The use stage related to the operation of the building shall account for B6 and B7:

- B6: Energy use to operate building integrated technical system

The module B6 shall include the life cycle of energy use during the operation of the integrated building technical system, together with its associated environmental aspects and impacts including processing and transportation of any waste arising on site from the use of energy [EN 15804, Clause 6.3.4.4.3].

- The ESL of the building in North America is defined as 60 years.
- The thickness and R-value of the gypsum boards are listed in Tables 6 and 7, respectively;
- Due to the complexity of building energy modeling, building science specialist(s) shall conduct the analysis and provide maximum transparency by specifying, (e.g. climate region, building structure and envelope, calculation methods, software/tools), the most recent national standards and other key technical parameters which shall allow for verification of the results.

This PCR defines that the state-of-art (current technology) gypsum board alone (in itself) has null impact on the energy use to operate the building integrated technical system during the assumed 60 year service life of the building in NA⁹.

- B7: Operational water use by building integrated technical system

The module B7 shall include water use during the operation of the integrated building technical system, together with its associated environmental aspects and impacts considering the life cycle of water including production and transportation and wastewater treatment [EN 15804, Clause 6.3.4.4.3].

This PCR defines that gypsum products have null impact on the operational water use by building integrated technical system during the 60 year ESL of a building in NA.

Use stage (B6 and B7) related to the operation of the building shall include provision and transport of all materials, products, as well as energy and water provisions, waste

⁹ Note that this PCR is unable to provide guidance, rules or recommendations for phase change materials. While gypsum board phase change materials are being investigated by the gypsum board industry, they are presently in the Research & Development phase and any relevant data is incomplete and proprietary. A date certain for the release of gypsum board phase change materials into the marketplace is indeterminate at this time.

processing up to the end-of waste state or disposal of final residues during this part of the use stage.

All state-of-art gypsum board EPDs that include the use stage should include a statement to the effect that “use stage impacts of the whole building integrated technical system are modeled for a specific scenario and are only comparable with products developed using the exact same use stage scenarios”.

C1-C4 End-of-life stage

End-of-life stage shall account for:

- C1: Deconstruction, demolition
- C2: Transport to waste processing
- C3: Waste processing for NA gypsum board industry practices. This PCR supports the scenario that all gypsum board products shall be disposed in an appropriate construction and demolition landfill at end of life.
- C4: Disposal

Based on the normal NA gypsum board industry practices, this PCR supports the scenario that all gypsum board products shall be disposed in an appropriate construction and demolition landfill at end of life. This means:

- C1 shall include the energy for gypsum board product deconstruction including demolition and released dust in air;
- C2 shall include the transportation of gypsum board waste from the building to construction and demolition landfill site;
- C3 shall be excluded as no gypsum board waste goes to waste processing facility for reuse, recovery, and/or recycling;
- C4 shall include the disposal of gypsum board waste in construction and demolition landfill site.

The end of life stage (C1 to C4) includes provision of all materials, products, related energy and water use, and gypsum board waste disposal. C1 to C4 key parameters must be clearly stated and the GA/manufacturer should have supporting documentation to justify the reported values.

D Benefits and loads beyond the system boundary, information module

Module D includes reuse, recovery and/or recycling potentials, expressed as net impacts and benefits.

Based on the normal NA gypsum board industry practices, this PCR specifies that no benefits or loads other than those associated with transporting the waste material to the construction and demolition landfill site (C2) and with the operation of the construction

and demolition landfill (C4) shall take place. No recycling potential credits are applicable or allowed.

11.4 Data quality requirements

The data quality has an influence on the content of an EPD. Data quality requirements shall be addressed in the LCA project report in conformance with ISO 14044, Clause 4.2.3.6 and ISO 14025.

In addition the following specific requirements apply for gypsum board products:

- Data shall be as current as possible. Data sets used for calculations shall have been updated within the last 10 yrs for generic *data* and within the last 5 yrs for GA's average and manufacturer's average or specific data;
- An industry average gypsum board EPD shall be based on representative average data of the products declared within the EPD;
- A specific gypsum board product shall be based on specific data for the processes that the producer of the specific product directly controls.
- Both average and company specific data set shall be based on annual data representative of 12 consecutive operating months; Deviations shall be justified.
- If a manufacturer produces a specific gypsum board EPD for multiple facilities, a weighted average based on total annual production in million sf of each facility shall be used as the basis for calculating the average. The variability of LCA results should be documented in the LCA report as an uniform range and display a minimum value to a maximum value. [e.g. climate change 1 kg CO₂.; range (0.8, 1.2)].
- In cases where several similar gypsum board products are produced by a facility or company, the PCR offers the possibility for similar products to be grouped as an "average gypsum board product" in the same EPD provided that the difference between their LCA results is equal to or less than 5% for each environmental parameter derived from LCA, as summarized in Table 16. In this case, the weighted average LCA results per each environmental parameter reported in EPD shall be calculated based on total annual production in million sf of each selected similar product in the sample. The variability of LCA results should be documented in the LCA report as an uniform range and display a minimum value to a maximum value. [e.g. climate change 1 kg CO₂ e.q.; range (0.96, 1.05)].
- The electricity grid for processes the manufacturer exercises control over should represent the appropriate regional or national electric grid data as published by the U.S. LCI Database¹⁰, ecoinvent, GaBi or other relevant national or international LCI database. Energy related "dummy"¹¹ LCI datasets shall be modeled substituting these data from alternate LCI databases or with appropriate proxies. All assumptions shall be

¹⁰ Link to U.S. Life Cycle Inventory Database: <http://www.nrel.gov/lci/>;

¹¹ "Reference the definition of "dummy" in Section 4.

documented in LCA report. The same approach is applicable for other upstream and downstream processes.

- Where the unit process is powered by on-site generated renewable (e.g. wind, solar, bio-based) or non-renewable (e.g. natural gas) electricity and no electricity leaves the facility (i.e. the system is not grid-linked), on-site generated electricity shall be accounted for in the system. Evidence shall be provided that the practice has been in place for the last three years in reference to the data collection year or that it will be the practice for the next 5 years (including the data collection year).

- Where the unit process is powered by purchased renewable electricity it may be accounted for in the system. Evidence shall be provided that the practice has been in place for the last three years in reference to the data collection year or that it will be the practice for the next 5 years (including the data collection year).

- If specific data are not available, GA industry *average LCI* data shall be used for raw gypsum quarrying and mining, gypsum paper production, and FGD provision at the manufacturing gate.

- Generic LCI data may be used for other processes the producer can't influence (e.g. processes dealing with the production of other input commodities such as dry and wet additives, electricity generation, natural gas extraction and combustion), often referred to as upstream processes, and for downstream processes such as waste and wastewater treatment. Generic LCI data should represent the most appropriate regional or national data sets as published by the U.S. LCI Database, ecoinvent, GaBi or other relevant national or international LCI database. "Dummy" LCI datasets shall be modeled substituting these data from alternate LCI databases or with appropriate proxies. All assumptions shall be documented in the LCA report.

- When an average product is declared, the additional technical and environmental information for the development of scenarios of the building's life cycle stages (construction, use and end-of-life) shall be specific or average information.

- Documentation of technological, geographical and time related representativeness for generic data shall be provided in the LCA project report.

- Data sets shall be complete according to the system boundary within the limits set by the cut-off rules (see section 11.5).

11.5 Cut-off rules

The following procedure shall be followed for the exclusion of inputs and outputs:

- All inputs and outputs to a unit process, for which data are available, shall be included in the calculation. Data gaps may be filled by conservative assumptions with average or generic data. Any assumptions concerning such value choices shall be documented.

- In cases of insufficient input data or data gaps for a unit process, the cut-off criteria shall be 1% of total primary energy usage and 1% of the total mass input of that unit process;

- The total of neglected input and output flows per each group module: A1-A3, A4-A5, B1-B5, B6-B7 and C1-C4 (see Figure 1) shall not exceed a maximum of 5% of energy usage, mass or environmental impact category indicator covered by this PCR (see Table 3).

- Conservative assumptions in combination with plausibility considerations and expert judgments should be used to demonstrate compliance with these criteria.

All hazardous and toxic materials and substances shall be included in the inventory, and the cut-off rules do not apply [ISO 21930].

11.6 Units

SI units should be used for the Life Cycle Calculations:

- Preferred basic units are:

- kg (kilogram)
- MJ (Mega Joule) for thermal energy
- kWh (kilowatt-hour) or MJ for electrical energy
- m² (square meter) for gypsum board surfaces
- km (kilometer) for transportation distance

Table 2 summarizes the mandatory conversion factors to be used by the PCR users.

Table 2 Mandatory conversion factors

Convert from (US units)	To (SI units)	Multiply by (5-significant digits)
Pound (lb)	Kilogram (kg)	0.45359
British Thermal Unit (BTU)	Joule (J)	1055.0
Inches (in)	Millimeter (mm)	25.400
Foot (ft)	Meter (m)	0.30480
Square foot (ft ²)	Square meter (m ²)	0.092903
Cubic foot (ft ³)	Cubic meter (m ³)	0.028316
Specific density (lb/ft ²)	Specific density (kg/m ²)	4.88240
Mile (mi.)	Kilometer (km)	1.60934
R- thermal resistance (ft ² ·°F·hr/ Btu)	R- thermal resistance (m ² K/W)	0.17611

12 Life Cycle Inventory Analysis

12.1 Data collection

In conformance with ISO 21930, Clause 6.2.1 and ASTM E 2129, data collection shall follow the guidance provided in ISO 14044, Clause 4.3.2. The qualitative and quantitative data for inclusion in the inventory shall be collected for each unit process that is included within the selected modules for the declared system boundary (EPD scope). The collected data, whether measured, calculated or estimated, are utilized to quantify the inputs and outputs of a unit process. When data have been collected from public sources, the source shall be referenced. For those data that may be significant for the conclusions of the study, details about the relevant data collection process, the time when data have been collected, and further information about data quality indicators shall be referenced. If such data do not meet the data quality requirements (see section 11.4), this shall be stated. Since data collection may span several reporting locations and published references, measures should be taken to reach uniform and consistent illustration of the modeled product system. These measures should include:

- Inclusion of process flow diagrams that outline all the unit processes or modules included in the model, including their respective linkages to the other modules;
- Listing each unit process's significant inputs and outputs;
- Describing the data collection techniques employed for all data; and
- Documenting any special cases, irregularities or other items associated with the collected data.

The inventory data collected shall be flow-based, complete and follow ISO 14044 requirements. Data shall be representative of the commissioner's intended EPD scope according to temporal, geographical and technological requirements (see Section 11.4).

12.2 Data sources

As a general rule, specific and average data shall be the first choice as a basis for calculating a LCI to support the intended EPD scope. The use of generic data for either upstream or downstream processes shall be justified. These data sources are governed by the data quality requirements in Section 11.4.

Sources of all data shall be readily available, accurate, and documented in the LCA report underlying the EPD for verification purposes. For an EPD based on average data, the representativeness of the data shall be justified in the underlying LCA report supporting the verification of the EPD.

12.3 Calculation rules

The calculation procedures described in ISO 14044, Clause 4.3.3 shall apply. The calculation procedures shall be applied consistently throughout the study.

When transforming the inputs and outputs of combustible material into inputs and outputs of energy, the higher heating value of fuels shall be applied according to scientifically based and accepted values specific to the combustible material.

All calculation procedures shall be explicitly documented in the supporting LCA report and any assumptions made shall be clearly stated and explained. Any and all assumptions will be documented in the EPD.

Care should be taken when aggregating the inputs and outputs within the product system. The level of aggregation shall be consistent with the goal of the study – single facility, company wide or industry average.

If several gypsum board products are declared in one EPD or if one product is produced at several locations, modeling must be done for each product or location, and the method for weighting of the data sets across facilities shall be based on the total annual production in million sf of the product(s) of interest.

12.4 Allocation rules

In many industrial processes, the intended product is co-produced with other products. Normally the input flows are not distributed between them in a simple way. Intermediate and discarded products can be recycled to become inputs for other processes.

- In this PCR, the allocation procedures in general and allocation procedures for reuse and recycling shall follow the requirements and recommendations given in ISO 14044, clause 4.3.4;
- The ISO 21930 principle of modularity shall be maintained; where processes influence the product's environmental performance during its life cycle, they shall be assigned to the life cycle stage where they occur.
- Further, the sum of the allocated inputs and outputs of a unit process shall be equal to the inputs and outputs of the unit process before allocation. This means no double counting or omission of inputs or outputs through allocation is permitted.
- All ISO 14044-conformance allocation rules applied for upstream data, manufacturer's average or specific data and downstream data shall be clearly stated and justified in the supporting LCA report;

The following allocation rules shall be applied for this PCR in regard to the following processes:

- Quarry production system: Mass shall be applied as the most appropriate physical parameter for allocation of the total environmental load of the quarry system between *quarried gypsum* (product) and the "solid rock sold to other industries" (co-product);
- Gypsum Paper production system: Mass shall be applied as the most appropriate physical parameter for allocation of the total environmental load of gypsum paper system between gypsum paper (product) and the "downgraded and side-rolls" co-products.

- Gypsum board manufacturing is a complex technical system with a wide range of input materials and gypsum product outputs. Plant specific generic formulations for unit of surface of the products of interest should be used to calculate the required input raw (both primary and secondary) and ancillary materials. Mass shall be used as the most appropriate physical parameter for allocation among different gypsum products of the gypsum board system.

- FGD gypsum, a co-product of the coal-fired power generation process, is a significant input used in the manufacture of NA gypsum board. As clearly stated, justified and documented in the GA LCA final report 2011¹², “system expansion” shall be applied as the most appropriate approach to solve the multi-functionality of the coal-fired power generation process. ISO 14044, clause 4.3.4 recommends this approach as step 1. Neither the correct physical nor economic allocation factor can be effectively or consistently applied.

Figure 5 describes the system expansion approach applied for the FGD gypsum co-product generated at coal-fired power plants. Based on the US statistics, the supply for FGD gypsum is already higher than the demand which means that FGD gypsum is not fully used. For that reason, the gypsum board production system (Module A3) is debited for intermittent treatment of FGD gypsum (de-watering, transportation) and credited for avoided landfilling of FGD gypsum, and the coal-fired power generation process (A) is debited for FGD gypsum landfilling¹³.

Environmental burden of Product - Electricity, from coal = Process E + Process W

Environmental burden of Product- Gypsum board = Module A3 + Process I - Process W

Figure 6 describes the system expansion approach applied for the post-consumer gypsum material (recycled gypsum from gypsum board on-site construction off-cuts). Post consumer gypsum material collected from construction sites isn't always fully utilized, and part of it is regarded as waste. For that reason, the gypsum board production system (Module A3) is debited for intermittent treatment (collection, transportation and plant specific processing) of the post-consumer gypsum input and credited for the avoided waste disposal and transportation to landfill of the post consumer gypsum waste according to the LCA system expansion rules.

¹² Gypsum Association LCA Final report, 2011: A Cradle-to-Gate Life Cycle Assessment of 1/2" Regular and 5/8" Type X Gypsum Wallboards, Section 3.2.4 Allocation methods, and Appendix A: Case Studies on Allocation Procedures

¹³ In instances where gypsum board manufacturers don't have access to supplier specific FGD LCI data they shall use the respective rolled up average GA FGD LCI data, provided by GA upon request.

Figure 5 System expansion approach for the FGD gypsum

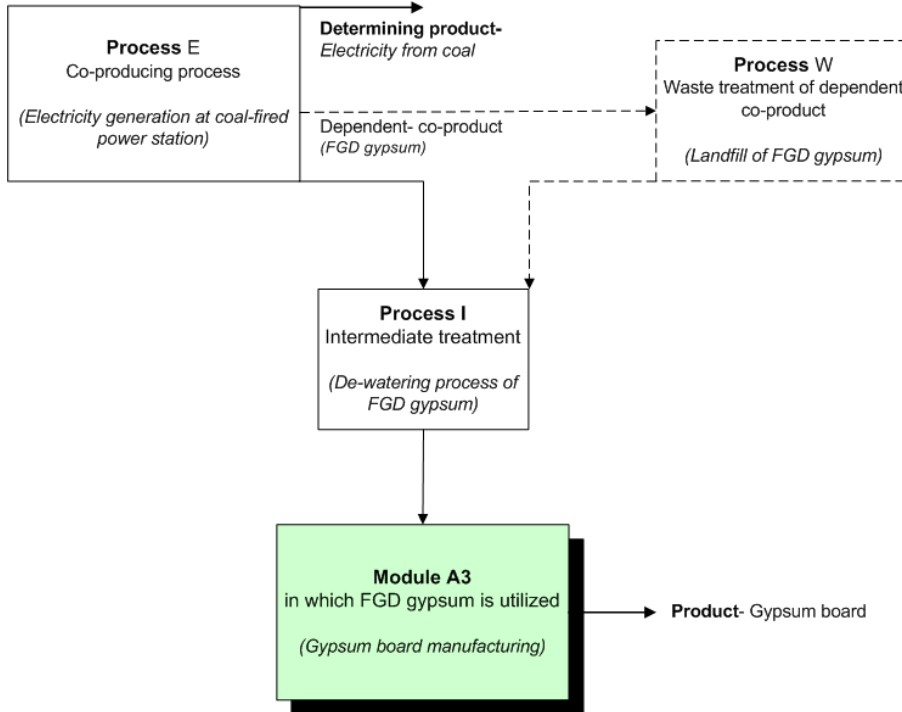
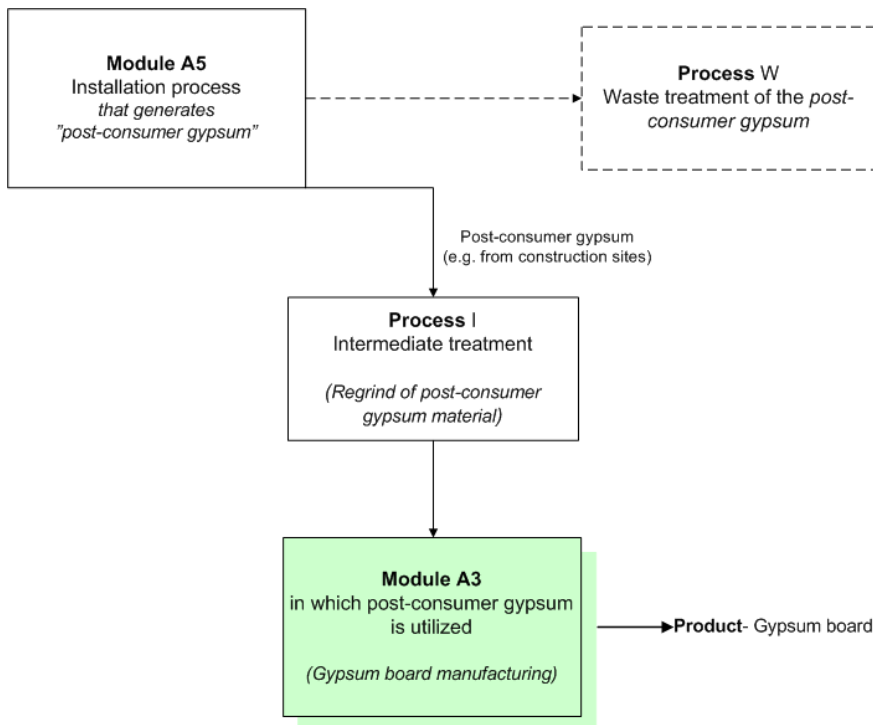


Figure 6 System expansion approach for the post-consumer gypsum material



13 Environmental Parameters derived from LCA

In conformance with ISO 21930 and EN 15804, this PCR covers all required environmental impacts, use of resources and generation of waste as specified in ISO 21930, Clause 8.2.2, and EN 15804, Clauses 7.2.2-7.2.5.

13.1 Parameters describing environmental impacts

These pre-determined environmental impact parameters are required and shall be included in all gypsum board EPDs as follows:

Table 3 Parameters describing environmental impacts

Impact category	Parameter	Unit (per FU or DU)	Source of the characterization method	Level of site specificity selected	Environ- mental media
Climate change ^{1,2)}	Global warming potential(GWP)	kg CO ₂ – equiv.	TRACI 2.1, July 2012 /IPCC 2007	Global	Air
Ozone depletion ^{1,2)}	Depletion potential of the stratospheric ozone layer(ODP)	kg CFC-11 equiv.	TRACI 2.1, July 2012/WMO:2003	Global	Air
Acidification ^{1,2)}	Acidification potential(AP)	kg SO ₂ equiv.	TRACI 2.1, July 2012	North America	Air, Water
Eutrophication ^{1,2)}	Eutrophication potential(EP)	kg N equiv.	TRACI 2.1, July 2012	North America	Air, Water
Smog ^{1,2)}	Photochemical ozone creation potential(POCP)	kg O ₃ equiv.	TRACI 2.1, July 2012	North America	Air
Depletion of abiotic resources – fossil fuels ²⁾	Abiotic Depletion potential(ADP)- fossil fuels	MJ surplus energy ⁴⁾	TRACI 2.1, July 2012 /eco-indicator 99 LCIA methodology ³⁾	Global	Natural resources

Notes:

(1) Required in ISO 21930, Clause 8.2.2.1.

(2) Required in EN 15804 Clause 7.2.3.

(3) A non site-specific recommendation for fossil fuel use characterization was included within the original version of TRACI (Bare et al. 2003, Goedkoop&Spriensma 1999) and this reference methodology is maintained within the release of TRACI 2.1, July 2012 [U.S EPA 2012].

(4) Surplus energy per extracted MJ, kg or m³ fossil fuel, as a result of lower quality resources.

13.2 Parameters describing resource use

The parameters describing resource use based on LCI shall be included in the EPD as follows:

Table 4 Parameters describing resource use

Parameter	Unit (per FU or DU)
Non-renewable resources	
Use of <u>non-renewable primary energy resources</u> (NRPE) (excluding NRPE used as raw materials)	MJ, gross heat content
NRPE, fossil (NRPE-F)	MJ, gross heat content
NRPE, nuclear (NRPE-N)	MJ, gross heat content
Use of <u>NRPE used as raw materials</u> (NRPE-M)	MJ, gross heat content
Use of <u>non-renewable secondary fuels</u> (NRSF)	MJ, gross heat content
Use of <u>non-renewable material resources</u> (NRMS)	kg
Renewable resources	
Use of <u>renewable primary energy resources</u> (RPE) (excluding RPE used as raw materials)	MJ, gross heat content
Use of <u>RPE used as raw materials</u> (RPE-M)	MJ, gross heat content
Use of <u>renewable secondary fuels</u> (RSF)	MJ, gross heat content
Use of <u>renewable material resources</u> (RMS)	kg
Use of secondary material (SM) (e.g. FGD gypsum, pre- or post-consumer gypsum etc.)	kg
Net use (consumption) of fresh water (NUFW)	m ³

Notes:

(1) Section 13.2 combines all requirements set out in ISO 21930, Clause 8.2.2.2 and EN 15804, Clause 7.2.4 and additional recommendations in ISO 21930, Clause 8.2.6 in regards to LCI parameters covering the resource use; It should be mentioned that ISO 21930 requires a higher rolled up level of LCI indicators without requesting a specific breakdown of e.g. non-renewable energy resources in primary, secondary and feedstock energy (NRPE used as raw materials). On the other hand, EN 15804 requires a more detailed breakdown of resource use indicators. ISO 21930 recommendations on providing a breakdown of resources by type e.g. fossil energy, nuclear energy etc are considered as well.

This PCR requires mandatory reporting of gross heat content (HHV) The reporting of net heat content (LVH) is optional.

The PCR user shall report all the relevant flows per parameter describing resource use, as specified in Table 4, in the underlying LCA report for EPD.

13.3 Other environmental information describing different waste categories and output flows

The parameters describing waste categories and other material flows shall be derived from the LCI and be included in the EPD as follows:

Table 5 Parameters describing different waste categories and output flows¹⁾

Parameter	Stages	Unit (per FU or DU)
Waste categories		
Hazardous waste disposed (HWD)	For each of declared stages	kg
Non hazardous waste disposed (NHWD)	For each of declared stages	kg
Radioactive waste disposed (RWD)	For each of declared stages	kg
Output flows		
Components for re-use (CRU) ²⁾	End-of-life stage	kg
Materials recycling (MR) ²⁾	End-of-life stage	kg
Materials for energy recovery (MER) ²⁾	End-of-life stage	kg
Material for disposal to landfill (MDL)	End-of-life stage	kg

Notes:

(1) Section 13.3 combines all requirements set out in ISO 21930, Clauses 8.2.2.3 and 8.2.4, and EN 15804, Clause 7.2.5, in regards to LCI parameters covering the resource use and output flows. Output flow parameters are also part of the additional information for scenarios at end-of-life. See section 19.4, Table C1-C4- End-of-Life.

Based on the normal NA gypsum board industry practices, this PCR supports the scenario that all gypsum board products shall be disposed in a construction and demolition landfill at end-of-life. No claims related to CRU, MR and MER of gypsum board waste at the end-of-life stage shall be declared.

The PCR user shall report all the relevant flows per parameter describing waste categories and output flows (as specified in Table 5) in the underlying LCA report for EPD.

- Indicators declared in the individual information modules of a product life cycle A1 to A5, B1 to B7, C1 to C4 and module D as described in Figure 1 shall not be added up in any combination of the individual information modules into a total or sub-total of the life cycle stages A, B, C or D. As an exception, information modules A1, A2, and A3 may be aggregated.

14 Additional technical and environmental Information

In conformance with ISO 21930 and EN 15804, this PCR also addresses two additional categories of information which are not derived from LCA

- Additional technical information for the optional “construction, use and end-of-life” life cycle stages- see Section 19.4.
- Additional environmental information during the use stage which is not covered by the LCIA - see Section 19.7.

15 Ownership, responsibility and liability for the EPD

The commissioner of the EPD (e.g. GA, an individual GA member company) is the sole owner and has liability and responsibility for the published EPD.

16 Verification and validity of the EPD

Any verified EPD completed following the gypsum board PCR outlined in this document is valid for a 5-year period from the date of issue, after which it shall be reviewed and re-verified. The EPD shall only be reassessed and updated as necessary to reflect changes in technology or other circumstances that could alter the content and accuracy of the declaration.

The results of the EPD may not have to be recalculated after 5 years, if the underlying data has not changed significantly.

The EPD shall be updated after 5 years, if the underlying data has changed significantly.

A significant change in data is a change of 10% or greater in any of the environmental parameters derived from LCA.

In cases of revisions to this PCR (see section 6), an existing EPD will be valid for 6 more months from the date of publication of the revised PCR.

The process for verification and establishing the validity of an EPD shall be in accordance with ISO 14025 and ISO 21930.

17 Comparability of EPDs

In conformance with ISO 14025, Clause 7.2.1, a statement shall be included in any gypsum board EPD that indicates, “environmental declarations from different programs may not be comparable” (see Section 19.3.7).

In conformance with ISO 21930, Clause 5.6, the comparison of the environmental performance of gypsum boards using the EPD information shall be based on the product's use in and its impacts on or within the building and shall consider the complete life cycle (all information modules).

This PCR also addresses core issues in ISO 14025 Section 6.7.2 Requirements for Comparability. Full conformance with this PCR ensures EPD comparability when all stages of a products life cycle have been duly considered; however, variations and deviations are possible. The EPD owner shall transparently indicate any comparability limitations.

18 LCA study report on the declared product

ISO 12930, Clause 7.2 refers to the LCA study report on the declared product as a "project report"¹⁴.

The project report shall be prepared in accordance with the requirements and guidance of ISO 14044, Clause 5.2, for third-party reports. The project report shall contain any data and information of importance for the data published in the EPD and as required in this PCR.

As required in ISO 14025, Clause 6.8.2, the quantified environmental information in Type III environmental information shall be based on:

- Results from one or more LCA in accordance with the ISO 14040 series of standards, or
- Information modules, if used.

¹⁴ Please reference Gypsum Association LCA Final report, 2011: A Cradle-to-Gate Life Cycle Assessment of 1/2" Regular and 5/8" Type X Gypsum Wallboards.

19 Content of the EPD

- Title page

Title page shall contain the following information:

- Reference to: “Environmental Product Declaration according to ISO 14025”
- Name of the declared product
- Name of the gypsum board manufacturer or GA
- Owner of the Declaration
- Name of the EPD Program operator
- Name of the EPD publisher
- Declaration number
- Date of issue of the declaration
- Date of validity of the declaration (5 year period)
- An adequate image of the product

1. “General information” section

In this section, the following general information shall be reported:

- The name and address of the GA/ manufacturer	- Name of the gypsum board product(s)
- The name and address of the EPD Program operator	- The name and address of the owner of the declaration
- Declaration number	- “Declared product” and DU or FU
- Name of the PCR, including the version	- Scope of the EPD declaration The gypsum board product (s), plants and their locations on which data the LCA is based and for which the EPD applies must be outlined. In the instance where an EPD declares an average performance for a number of products, it shall include a statement that the EPD document represents an average performance. In addition, information on the deviation of the products’ performance with respect to the average shall be stated. For sector average EPDs (e.g. GA EPDs) this type of EPD must be referred to. The EPD-type shall be declared according to Table1. If the declaration is not based on an LCA covering all stages, specify which life cycle stages are not considered.
- Date of issue of the declaration	- Date of validity of the declaration
- Include information about where explanatory information about the EPD content can be obtained (e.g. by referring to the PCR and GPI documents, EPD Program operator, contact person of the GA/manufacturer EPDs)	

In conformance with ISO 21930, Clause 8.1 and ISO 14025, Clause 7.2 the following information shall be clearly provided in the Type III environmental declaration.

PCR review, was conducted by: <name and organization of the chair, and information on how to contact the chair through the programme operator>
Independent verification of the declaration and data, according to ISO 14025:2006 and ISO 21930:2007 internal external
(Where appropriate) Third party verifier: <name of the third party verifier>

As specified in ISO 14025, Clause 9.4 and ISO 21930, Clause 5.4, third party verification is optional for B to B communication and mandatory for B to C communication.

2. “Product” section

The product section shall contain the following information:

2.1 Product description

The declared gypsum board product(s) must be described.

2.2 Designated Application

The designated application for the gypsum board product(s) referred to must be specified.

2.3 Product data

Product data including sizes, density and types must be declared.

Table 6 Summary of the general data for gypsum boards

Product Data: Sizes and Types	Thickness - in inch [mm]	Specific density -in lb/ ft ² [kg/m ²]	Core type	ASTM Standard
Specify the ASTM C 1396 sub-category (see Section 8) of the declared product (e.g. Gypsum board)	e.g. ½-inch [x mm]	e.g. 1.6 lb/ft ² [z kg/m ²]	e.g. Regular	C1396

2.4. Technical Data

The following technical data must be provided for gypsum board products with reference to the test standard.

Table 7 Summary of the technical data for gypsum boards

Technical data	Value and Units/Test Results/ /Statement	Referenced documents and links
"R" factor- thermal resistance in US unit [SI unit]		e.g. ASTM E136
Material Safety Data Sheet- Yes/No		Available at (link)
Mold resistance (if applicable)		ASTM C1396
Water absorption (if applicable)		ASTM C473, ASTM C1396
Total water absorption (if applicable)		ASTM C473, ASTM C1396
Surface burning characteristics (if applicable)		e.g. ASTM E 84
Flame Spread		ASTM C1396
Smoke Developed		
Foil Application ¹⁾ : (if applicable), Desiccant Method Test		ASTM C1396
Abuse/impact resistance test (if applicable)		ASTM C1629
Total Recycled Content (%)		As defined in ISO 14021
Pre-consumer (%)		
Post-consumer (%)		

Notes: 1) Foil may be applied to the back of ASTM C 1396 gypsum board for the purpose of complying with ASTM C 1396 paragraph 5.1.

2.5 Placing on the market / Application rules

The respective standard and/or general technical approval or national regulation must be indicated. Standards must be quoted as illustrated in the example shown:

e.g. ASTM C1396:2011, Standard Specification for Gypsum Board

2.6 Product formulation

For sector average EPDs, products formulation (in kg/1,000 sq. ft.) shall be indicated to enable the user of the EPD to understand the composition of the gypsum board product as delivered.

(see Table 9, GA LCA Final report, 2011: A Cradle-to-Gate Life Cycle Assessment of ½" Regular and 5/8" Type X Gypsum Wallboards)

For confidentiality reasons, the declaration of the product formulation is optional for plant specific EPDs. Either the product formulation or the MSDS of the product must be declared. If one exists, also include health product declaration.

2.7 Manufacturing

Unit processes included in the manufacturing process shall be reported (e.g. secondary crushing, screening, gypsum drying and conveying, calcining, dry and wet mixing, board lay-up, scoring and chamfering, board drying, cutting and stacking, packaging and bundling).

If reported using an illustration, a simple diagram is sufficient. If applicable, quality management systems in place can be referred to.

2.8 Environment and health during manufacturing

Declaration of the environmental pollution abatement equipment installed at the surveyed plants to control particulate matter (PM) emissions (e.g. fabric filter - high temperature (baghouses).

Any other environmentally friendly practice dealing with emissions to air, water, and soil or waste treatment can also be reported.

If an Environment Management System is in place, it can be referred to.

2.9 Packaging

Information on product-specific packaging:

- Type of packaging (e.g. 2 pieces per bundle, face-to-face, end labeled), and
- Packaging materials (paper end tape, shrink-wrap, steel banding).

2.10 Product installation

A short description of the installation process, joint compounds used in the installation, and any ancillary inputs is recommended.

If applicable, installation methods/ practices for dust extraction and/or noise reduction can be reported.

2.11 Environment and health during use stage

Any possible product related emission (e.g. VOCs and asbestos) should be reported in conformance with the result tests (see section 19.7).

2.12 Reference service life

RSL shall be specified as described in Section 11.2.

2.13 End-of-Life

As specified in Section 13.3, at the end-of life, gypsum boards are disposed to building and construction landfill.

2.14 Further information (optional)

Including links to further product related information or to the manufacturer homepage is possible.

3. LCA: Calculation rules

3.1 Declared or Functional Unit

The following table shall be completed:

For “cradle to shipping gate”, “cradle to building- (Option 1)” and “cradle to building- with EOL stage (Option 2) EPDs, declared unit shall be reported and Table 8 shall be completed.

Table 8 Declared unit for gypsum boards

Gypsum boards with specified thickness in y inches (x mm)	Value and units
Declared unit	1000 sf
Conversion factor to kg	

For “cradle to grave” and “cradle to building- with use stage (option 3)” EPDs, FU shall be defined as described in Section 11.1.

3.2 System boundary

Type of the EPD (see Table 1) shall be reported including the respective modules considered.

Any exception from the requirements set out in Section 11.3 System boundaries (e.g. exclusion/inclusion of processes), shall be reported here.

3.3 Estimates and assumptions (optional)

Key assumptions and estimates for conducting the LCA should be referred to here provided that they are not dealt with in other sections of the content of the EPD.

3.4 Cut-off criteria

Applied cut-off criteria shall be documented here (see Section 11.5).

3.5 Data requirements and data sources

Statements shall be made in regard to fulfilling the PCR's data requirements (section 11.3) and the data types (generic, manufacture's specific or average) used for upstream and downstream processes (if applicable) and processes the manufacturer(s) has influence over (see Section 12.2).

3.6 Allocation

Applied allocation rules shall be documented here (see Section 12.4).

3.7 Comparability of EPDs

ISO 14025 requires a statement to be included that indicates, "Environmental declarations from different programs may not be comparable".

In conformance with ISO 21930, Clause 5.6, a statement should be included that indicates, "the comparison of the environmental performance of gypsum boards using the EPD information shall be based on the product's use in and its impacts on or within the building, and shall consider the complete life cycle (all information modules)".

All gypsum board EPDs that include use stage should include a statement to the effect that "*use stage impacts of the whole building integrated technical system are modeled for a specific scenario and are only comparable with products developed using the exact same use stage scenarios*".

Full conformance with the PCR for North American Gypsum Boards ensures EPD comparability when all stages of a product's life cycle have been duly considered; however, variations and deviations are possible".

The EPD owner shall transparently indicate any comparability limitations here.

4. LCA Scenarios and additional technical information

Tables 9 to 15 summarize the technical information that shall be declared if the EPD covers any of the following modules: A4-A5- construction stage; B1-B7- use stage and C1-C4- end-of life stage. Alternatively, in the cradle-to-gate EPD, a manufacturer may choose to declare additional technical information without calculating optional life cycle stages to ensure proper understanding of a product's function in a building and thus support proper scenario development at the building level.

Table 9 A4 module- Construction stage - Transport to the building site

Technical factors	Value	Units (per FU or DU)
Liters of fuel		l/100km
Transportation distance		km
Capacity utilization (including empty returns)		%
Gross density of transported products		kg/m ³

Table 10 A5 module- Construction stage- Installation in the building

Technical factors	Value	Units (per FU or DU)
Ancillary inputs for installation		kg
Water use		m ³
Other resource use		kg
Electricity consumption		kWh
Other energy carriers		MJ
Waste material resulting from installation		kg
Waste materials (specified by type) and the following waste treatment (e.g. recycling, energy recovery, landfill);		
Dust in the air		kg

B1 module- Use stage- Use or application of the installed product (B1)

Information on B1 is covered under Section 19.2.11 and 19.7.

Table 11 B2 module- Use stage- Maintenance

Technical factors	Value	Units (per FU)
Information on maintenance: (Description or source where description can be found)		-
Maintenance cycle		Number/RSL
Water consumption		m ³
Ancillary inputs for maintenance		kg
Other resources		kg
Electricity consumption		kWh
Other energy carriers		MJ
Waste material resulting from maintenance (specify materials)		kg

Table 12 B3 module- Use stage- Repair

Technical factors	Value	Units (per FU)
Information on the repair process (Description or source where description can be found)		-
Information on the inspection process (Description or source where description can be found)		-
Repair cycle		Number/RSL
Water consumption		m ³
Ancillary inputs for repair		kg
Other resources		kg
Electricity consumption		kWh
Other energy carriers		MJ
Waste material resulting from repair (specify materials)		kg

Table 13 B4/B5 module- Use stage- Replacement/Refurbishment

Technical factors	Value	Units (per FU)
Replacement cycle		Number/RSL
Electricity consumption		kWh
Litres of fuel		l/100km
Replacement of worn parts or refurbishment materials		kg
Reference service life		years

Table 14 B6 and B7 module- Use stage- operational energy use and operational water use

Technical factors	Value	Units (per FU)
Water consumption		m ³
Electricity consumption		kWh
Other energy carriers		MJ
Equipment output		kW

Table 15 C1-C4 module- End-of-Life

Technical factors	Value	Units (per FU or DU)
Product waste collected separately		kg
Product waste collected as mixed construction waste		kg
Components for re-use (CRU)	0 ¹⁾	kg
Materials recycling (MR) ¹⁾	0 ¹⁾	kg
Materials for energy recovery (MER) ¹⁾	0 ¹⁾	kg
Material for disposal to landfill (MDL)		kg

Note (1): As specified in Section 11.3, C1 to C4 modules.

5. LCA Results

The LCA results table below consists of four parts:

- Part 1 "Description of the system boundary": all declared modules (included in LCA) shall be indicated with an "X"; all modules that are not declared (excluded from LCA) shall be indicated with "MND".
- Parts 2, 3 and 4: Columns should be deleted for modules that are not declared.
- When multiple modules are not declared and are deleted from the table, the full name of the parameters may be used (e.g. Global warming potential). In the instance where the full name of parameters are used, the legend at the end of Part 2, 3 or 4 of the table may be eliminated.
- If all modules are declared, then the abbreviations for the indicators (refer to Tables 3, 4 and 5) should be used (e.g. GWP, HWD). Furthermore, a legend should be provided respectively at the end of part 2, 3 and 4 of the table (e.g. GWP- Global Warming Potential; HWD-Hazardous waste disposal).
- Indicator values should be declared with three valid digits (eventually exponential form (e.g. 1.23E-5 = 0.0000123)). A uniform format should be used for all values of one indicator.

6. LCA Interpretation

Dominance analysis is recommended as analytical tool to concisely interpret the LCA results outlined in section 5 above (Part 2, 3 and 4) and to facilitate the comprehension and the reader's understanding of the environmental profile of the declared product.

A statement that “declarations based on this PCR are not comparative assertions; that is, no claim of environmental superiority can be inferred or implied” must be included in the interpretation.

7. Additional environmental information

The following additional environmental information may be provided for gypsum board products with reference to the test standard (optional).

Table 17 Additional environmental information (optional)

Additional environmental information	Test Results	Referenced documents and links
VOC test		e.g. the certificate of compliance is issued by X Laboratory, on (MM,YY). Available link (optional)
Asbestos test		e.g. the certificate of compliance is issued by X Laboratory, on (MM,YY). Available link (optional)

8. References

The references list shall quote as the minimum:

- (a) The Gypsum board PCR,
- (b) ISO 14025
- (c) ISO 21930
- (d) EN 15804
- (e) The relevant general standards for the declared gypsum board product(s)
- (f) The underlying gypsum board LCA report in conformance with ISO 14044.