Product Category Rules (PCR) For Preparing an Environmental Product Declaration (EPD) for:

RIGID AND FLEXIBLE BUILDING PIPING SYSTEMS IN NORTH AMERICA (PCR-1002)

The product group includes rigid and flexible plumbing and mechanical piping systems manufactured for use in North America

Date: February 1, 2019

REFERENCED PCR:

Product Category Rules (PCR) for preparing an Environmental Product Declaration (EPD) for Product Group: Piping systems for use for sewage and storm water (under gravity), NPCR 19, Norwegian EPD Foundation, September 2012. Including addendum updates.

Product Category Rules (PCR) for building products on an international market, Martin Erlandsson, Lars-Gunnar Lindfors, Sven-Olof Ryding B1617 March 2005, revised December 2005, Swedish Environmental Research Institute.

Product Category Rules (PCR) for Type III Environmental Product Declaration (EPD) of construction products to EN 15804:2012, BRE Global Limited, 2013.

Product Category Rules According to ISO 14025 for Construction Products and Construction Services (2012:01), International EPD System, March 2016.

Scope of Validity of these PCR

These PCR apply to rigid and flexible piping systems, including pipes, fittings and other materials used to install the system, for use in building piping applications in North America. 'Building applications' in the context of this PCR, refers to plumbing and mechanical piping systems commonly used in buildings in North America.

Program Operator

ICC Evaluation Service, LLC (ICC-ES) (https://icc-es.org/environmental-program/)

Interested Parties

Representatives of the Plastic Pipe and Fittings Association (PPFA), its member companies and other relevant associations participated in the development of the PCR. These companies and associations are listed in *Table 1* below. All companies and associations listed in *Table 1* were invited to provide input into the development of these PCR.

Table 1: PPFA Members and Relevant Associations

Processors	**Resin Suppliers**
Aquatherm, GmbH	Axiall Corporation
Arrow Adhesives Company	Dow Chemical Company
Bow Plastics	Formosa Plastics Corp. U.S.A.
Charlotte Pipe & Foundry Company	Ineos Olefins & Polymer, USA
Cresline Plastic Pipe Co. Inc.	Kaneka North America LLC
E-Z Weld, Inc.	Oxy Vinyls, LP
Georg Fischer Harvel, LLC	PolyOne Corporation
IPEX USA LLC	Saco Polymers Inc.
IPS Corporation	Shintech, Inc.
LASCO Fittings, Inc.	Teknor Apex
Mueller Industries, Inc.	The Lubrizol Corporation
National Pipe & Plastics, Inc.	Westlake PVC Corp.
NIBCO Inc.	**Ingredient/Additive Suppliers**
North American Pipe Corporation	Arkema Inc.

Oatey Co.	Galata Chemicals, LLC
RectorSeal Corporation	Holland Colours Americas, Inc.
Rocky Mountain Colby Pipe Co.	Honeywell Specialty Wax
Silver-Line Plastics Corp.	IMERYS Performance Minerals
Spears Manufacturing Company	KibbeChem, Inc.
T. Christy Enterprises	New Tech Color and Additives, LLC
Uponor	NORAC Additives
Viega LLC	Omya, Inc.
Zurn PEX	PMC Group
Machinery/ Other Suppliers	Reagans USA, Inc.
Advance Equipment Company	**Consultants**
battenfeld-cincinnati	Chasis Consulting
Extrusion Concepts LLC	IHS Chemical
Inoex, LLC	**Conformity Assessment Organizations**
Milacron Inc.	IAPMO Research and Testing
O.A. Newton	ICC Evaluation Service, Inc.
Plasmec USA	NSF International
Rollepaal, Inc.	
S&B Technical Products, Inc.	
United Plastics Machinery	

Review Panel

Chair and panel members with contact information.

The PCR peer review report is available upon request at:https://icc-es.org/environmental-program/environmental-product-declarations/.

1.0 General Information

These PCR have been developed under the general program instructions for the ICC-ES EPD Program. The PCR are intended for use by North American organizations and other interested parties that use the standards referenced in Section 5.2 for preparing EPDs for plumbing piping systems in North America.

In 2011, PPFA commissioned Franklin Associates to undertake an assessment of the environmental profiles of plastic pipes used in three types of piping applications in residential buildings. The life cycle stages evaluated include pipe and fittings material production and pipe and fittings fabrication, installation scenarios for several types of pipe systems in complete pipe layouts in three different home sizes, and use and end-of-life phases. The method used to conduct the assessment is consistent with ISO 14040 and ISO 14044 and the results were submitted to the BEES [(1)] database. The use phase, as well as the installation phase, required computer models (the Davis Energy HWSIM program) to

1 Building for Environmental and Economic Sustainability. National Institute of Standards and Technology. BEES software available for download at http://www.bfrl.nist.gov/oae/software/bees/

study the heat loss of the piping systems, and the work also determined that fittings were numerous enough in building piping to be relevant to the impacts, and necessary to include in any analysis.

The PCR which have been referred to in the development of this PCR for Piping Systems in North America are as follows.

1. Product Category Rules (PCR) for preparing an environmental declaration (EPD) for Product Group: Piping systems for use for sewage and storm water (under gravity), NPCR 19, Norwegian EPD Foundation, September 2012. Including addendum updates.

2. Product Category Rules (PCR) for building products on an international market, Martin Erlandsson, Lars-Gunnar Lindfors, Sven-Olof Ryding B1617 March 2005, revised December 2005, Swedish Environmental Research Institute.

3. Product Category Rules (PCR) for Type III Environmental Product Declaration (EPD) of construction products to EN 15804:2012, BRE Global Limited, 2013.

4. Product Category Rules According to ISO 14025 for Construction Products and Construction Services (2012:01), International EPD System, March 2016

5. The European Commission is working towards the development of a harmonized method for the calculation of the environmental footprint of products under the European Product Environmental Footprint scheme [(2)]. A series of pilots are currently underway, including one on the product category 'hot and cold water supply pipes'. One of the key tasks for the pilot is the development of PCR which, when published, will form the basis for the development of environmental profiles of hot and cold water supply pipes in Europe.

6. The United Nations Standard Products and Services Code (UNSPSC®) will serve as the framework for establishing product categories. In cases where inadequate distinction is present within the UNSPSC® to adequately distinguish product categories in the functional context of LCA and product declarations, the general UNSPSC® code will be supplemented with a separate identifier to define the unique characteristics of the product category in question.

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Table 2 sets out reasons why the referenced PCR are inappropriate for adoption or direct adaptation as PCR for Plumbing Piping Systems in North America.

2 http://ec.europa.eu/environment/eussd/smgp/

Table 2: Limitations of Referenced PCR for Plumbing Piping Systems in North America

1	Product Category Rules (PCR) for preparing an environmental declaration (EPD) for Product Group: Piping systems for use for sewage and storm water (under gravity)	• The referenced PCR is of too narrow a product scope, as it addresses only sewage and storm water pipes. The addendum making this applicable for North America applications expired in June 2016 and also states that the Addendum will no longer be needed once a North American PCR is completed. • The referenced PCR require listing *"as a minimum, substances contained in the product that are listed in the 'Candidate List of Substances of Very High Concern (SVHC) for authorization' when their content exceeds the limits for registration with the European Chemicals Agency."* Listing substances pertaining to the European Chemicals Agency is not standard practice in North America. • The referenced PCR refers to European technical data and standards, which are not applicable and potentially not permitted for use in North America.
2	Product Category Rules (PCR) for building products on an international market	• The referenced PCR refers to European technical data and standards, which are not applicable in North America. • The referenced PCR is of too narrow a product scope, as it focuses only on a cradle-to-gate life cycle assessment (LCA).
3	Product Category Rules (PCR) for Type III environmental product declaration (EPD) of construction products to EN 15804:2012	• The referenced PCR refers to European technical data and standards, which are not applicable in North America. • The referenced PCR require listing *"as a minimum, substances contained in the product that are listed in the 'Candidate List of Substances of Very High Concern (SVHC) for authorization' when their content exceeds the limits for registration with the European Chemicals Agency."* Listing substances pertaining to the European Chemicals Agency is not standard practice in North America.
4	Product Category Rules According to ISO 14025 for Construction Products and Construction Services (2012:01)	• The referenced PCR refers to European technical data and standards, which are not applicable in North America. • The referenced PCR require listing *"as a minimum, substances contained in the product that are listed in the 'Candidate List of Substances of Very High Concern (SVHC) for authorization' when their content exceeds the limits for registration with the European Chemicals Agency."* Listing substances pertaining to the European Chemicals Agency is not standard practice in North America.

5	Product Environmental Footprint Product Category Rules for Hot and Cold Water Supply Pipes (not yet published)	• The referenced PCR is not yet published and is therefore not yet available for use in developing an EPD. • It is likely that the referenced PCR will refer to European technical data and standards, which are not applicable in North America. • It is likely that the reference PCR will require listing *"as a minimum, substances contained in the product that are listed in the 'Candidate List of Substances of Very High Concern (SVHC) for authorization' when their content exceeds the limits for registration with the European Chemicals Agency."* Listing substances pertaining to the European Chemicals Agency is not standard practice in North America.

1.1 | GOAL AND SCOPE

This PCR specifies rules, requirements and guidelines for developing EPDs for rigid and flexible piping systems in building applications in North America and the underlying requirements of related life cycle assessments (LCAs). These PCR are valid for, and provide requirements for, both business-to-business (B2B) and business-to-customer (B2C) EPDs.

An EPD prepared under these PCR shall present results over some or all of the following phases of the life cycle, depending on whether the EPD is to be used for B2B, B2B with additional scenarios (e.g. estimated installation, use and disposal phases included), or B2C:

- raw materials acquisition and processing;
- manufacturing;
- transportation;
- installation;
- use and maintenance; and
- removal/disposal/reuse/recycling.

A reference service life (RSL) shall be stated in a B2C EPD to take account of the maintenance and replacement impacts over an assumed building service life. A RSL is permitted to be stated for a B2B EPD if a use phase scenario is included in the EPD. A RSL must be based on a verifiable performance history, as per the *Section 6.2 | System Boundaries*. The assumed building life is specified in these PCR as 50 years.

If the service life is declared, then the following principles shall apply:

- The RSL of a product can be based upon empirical, probabilistic, statistical, deemed to satisfy or research (scientific) data and shall always take into account the intended use (description of use), see ISO 15686 1, −2, −7 and −8. This basis shall be reported in the EPD;

- A manufacturer providing the RSL for a product shall take into account and describe in the EPD the intended use, declared functional performance and the scenario(s). Considering the specific in-use conditions linked to the scenario(s) defined, the estimated service life shall be transparent to allow for verification.

A declared RSL shall be related to the declared functional technical performance and to any maintenance or repair necessary to provide the declared performance during the declared RSL or provided ESL.

The RSL is dependent on the properties of the product and reference in-use conditions. These conditions shall be declared together with a RSL and it shall be stated that the RSL only applies to these reference in-use conditions.

The description of the technical and functional performance of a product is required for the technical specification of a construction product. The reference in-use conditions for achieving the declared technical and functional performance and the declared RSL shall include the following, where relevant:

- RSL expressed in years;
- declared product properties (at the gate) and those of any finishes, etc.;
- design application parameters (if instructed by the manufacturer), including references to any appropriate requirements and application codes;
- an assumed quality of work;
- external environment, (for outdoor applications), e.g. weathering, pollutants, UV and wind exposure, construction works orientation, shading, temperature;
- internal environment (for indoor applications), e.g. temperature, moisture, chemical exposure;
- usage conditions, e.g. frequency of use, mechanical exposure;
- maintenance, e.g. required frequency, type and quality and replacement of replaceable components.

These PCR are consistent with, and comply with, the mandatory requirements contained in the following standards.

- International Organization for Standardization (ISO) 21930: 2017 *Sustainability in building construction—Environmental declaration of building products.*
- ISO 14025:2006 *Environmental labels and declarations—Type III environmental declarations—Principles and procedures.*
- ISO 14040:2006 *Environmental management—Life cycle assessment—Principles and framework.*

ISO 14044:2006 *Environmental management—Life cycle assessment—Requirements and guidelines.*

ISO 21930:2017 will serve as the core of the PCR and subcategory PCR is in accordance with ISO 21930-2017 Section 6.3.

ISO 15686:2011 *BUILDINGS AND CONSTRUCTED ASSETS—SERVICE LIFE PLANNING,* PARTS -1, -2, -7 AND 8. While not necessarily complying with the CEN EN 15804 standard, this has been referenced and consulted upon with regard to selected requirements and presentation details that go beyond, or expand upon, the ISO standards noted above.

1.2 | EPD OWNERSHIP/RESPONSIBILITY

The producers or group of producers who develop an EPD following the PCR maintain sole ownership and have responsibility and liability for their EPD.

2.0 Period of Validity

This PCR document is effective for five (5) years from the latest date of publication. If after five years, relevant changes in the product category or other relevant factors have occurred (for example, changes in LCA methodology), the document will be revised. Revisions are permitted to also be made to these PCR during the period of validity. However such changes do not have to be reflected in existing EPDs during their validity period unless the EPD owners choose to do so.

An EPD created under the PCR shall be valid for a maximum five (5) year period from the date of issue after which it shall be reviewed and verified or in accordance with the program operator's instructions. An EPD shall be reassessed and updated as necessary, in order to reflect changes in technology or other circumstances that could alter the content and accuracy of the declaration. The process for verification and establishing the validity of an EPD shall be in accordance with ISO 14025, 14040 and ISO 21930.

3.0 Definitions

For the purposes of this document, the definitions given in ISO 6707-1, ISO 14025, ISO 14044, ISO 14050, ISO 15686-1, ISO 21930 and the following apply:

- *pipe* – a pipe used in plumbing or mechanical applications within a building;
- *fittings* – fittings used to connect pipes;
- *piping* – pipe or tubing used in plumbing or mechanical applications within a building;

- *mechanical applications* – piping used in ducts, combustion venting, pressure systems, refrigeration, hydronics, fire sprinkler, and condensate;
- *rigid piping* – building piping typically installed using elbows is to be considered rigid building piping; and
- *flexible piping* – building piping typically installed using pipe bends instead of elbows is to be considered flexible piping. Flexible building piping includes materials such as: PE/HDPE, PEX, and PERT, all one inch in size and under.

4.0 Informed Comparison

EPDs are permitted to enable comparison between products, but do not themselves compare products, as stated in ISO 14025 Sections 4 and 6.7.2. It shall be stated in EPDs created using these PCR that only EPDs prepared from cradle-to-grave life cycle results and based on the same function, reference service life (RSL) quantified by the same functional unit, and meeting all the conditions in ISO 14025, Section 6.7.2 shall be permitted to be used to assist purchasers and users in making informed comparisons between products. EPDs based on cradle-to-gate information modules shall not be used for comparisons unless they employ a common functional unit for the products examined and comply with the requirements of ISO 14025, Section 6.7.2 and ISO 21930, Section 5.5, when the product is used in buildings. EPDs based on a declared unit shall not be used for comparisons.

These PCR cover B2B, B2B with scenarios and B2C EPDs.

- If an EPD only covers B2B, then the following shall be stated in the EPD: *This EPD covers only the cradle-to-gate impacts of plumbing piping systems in North America using a declared unit and the results cannot be used to compare between products.*
- If an EPD covers B2C, then the following shall be stated in the EPD: *This EPD covers cradle-to-grave impacts of plumbing piping systems in North America using a functional unit.*

5.0 Company/Organization, Product and Product Category

5.1 | DESCRIPTION OF COMPANY/ORGANIZATION

The name of the company/ organization, as well as the place(s) of production, shall be provided in the EPD. The EPD are permitted to also include general information about the company/organization, such as the existence of quality systems, an environmental management system according to ISO 14001, or any other environmental management systems in place, as well as certification to the Sustainable Manufacturing Standard for Plastic Piping Systems Components, “Sustainable Manufacturing Standard (SMS-01-2012)

and "Sustainable Manufacturing Conformity Assessment Program for Plastic Piping Components" (SMCAP) http://www.ppfahome.org/smcabout.aspx.

5.2 | DEFINITION OF PRODUCT CATEGORY

These PCR address building piping systems in North America produced from the materials shown in, but not limited to, *Table 3*. Standards that provide detailed descriptions and specifications for each product or material are also listed. Building piping typically installed using elbows is to be considered rigid building piping. Building piping typically installed using pipe bends instead of elbows is to be considered flexible piping. Flexible building piping includes materials such as: PE/HDPE, PEX, and PERT, all one inch in size and under.

Table 3: Relevant Product and Materials Standards

PIPING PRODUCT OR MATERIAL	RELEVANT STANDARDS OR SPECIFICATIONS
Acrylonitrile butadiene styrene (ABS)	ASTM D1527; ASTM D2282; ASTM D2661; ASTM D2751; ASTM F628; ASTM F1488; ASTM F2806; CSA B181.1
Brass	ASTM B43
Cast iron	ASTM A74; ASTM A888; CISPI 301
Chlorinated polyvinyl chloride (CPVC)	ASTM D2846/2846M; ASTM F441; ASTM F442; CSA B137.6
Chlorinated polyvinyl chloride/ aluminum/ chlorinatedpolyvinyl chloride (CPVC/AL/CPVC)	ASTM F2855
Copper or copper-alloy	ASTM B42; ASTM B302; ASTM B75; ASTM B88; ASTM B251; ASTM B447; ASTM B135; ASTM B306
Cross-linked polyethylene (PEX)	ASTM F876; AWWA C904; CSA B137.5
Cross-linked polyethylene/ aluminum/ cross-linked polyethylene (PEX-AL- PEX)	ASTM F1281; ASTM F2262; CSA B137.10
Cross-linked polyethylene/ aluminum/ high-density polyethylene (PEX-AL-HDPE)	ASTM F1986
Ductile iron	AWWA C151/A21.51; AWWA C115/A21.15
Galvanized steel	ASTM A53
Polyethylene (PE)	ASTM D2737; AWWA C901; CSA B137.1;

	ASTM F714 ASTM D2239; ASTM D3035
Polyethylene/aluminum/polethylene (PE-AL-PE)	ASTM F1282; CSA B137.9; AWWA C903
Polyethylene of raised temperature (PE-RT)	ASTM F2769, CSA B137.18
Polypropylene (PP) plastic pipe or tubing	ASTM F2389; CSA B137.11
Polyolefin	ASTM F1412; CSA B181.3
Polyvinyl chloride (PVC)	ASTM D1785; ASTM D2241; ASTM D2672; ASTM D2665; ASTM D2949, ASTM D2729; ASTM D3034; ASTM F891; ASTM F1488; CSA B182.2; CSA B182.4; CSA B137.3; CSA B181.2; AWWA C900, AWWA C905
Oriented Polyvinyl Chloride (PVCO)	ASTM F1483, CSA B137.3.1, AWWA C909
Polyvinylidene fluoride (PVDF)	ASTM F1673; CSA B181.3
Stainless steel	ASTM A312; ASTM A778
Steel	ASTM A53; ASTM A106; ASTM A254
Vitrified clay	ASTM C4; ASTM C700

JOINING AND FITTINGS FOR PIPING MATERIALS	**FITTING, SOLDER and CEMENT STANDARDS**
Acrylonitrile butadiene styrene (ABS)	ASTM D2468; ASTM D2661; ASTM F628; ASTM D2751; CSA B181.1
Cast iron	ASME B16.4; ASME B 16.4; ASME B 16.12; ASTM A74; ASTM A888;CISPI 301
Chlorinated polyvinyl chloride (CPVC)	ASSE 1061; ASTM D2846; ASTM F437; ASTM F438; ASTM F439; CSA B137.6
Copper or Copper Alloy	ASME B16.15; ASME B16.18; ASME B16.22; ASME B 16.23; ASME B 16.26; ASME B 16.29; ASME B16.51; ASSE 1061; ASTM F1476; ASTM F1548
Cross-linked polyethylene/aluminum/high-density Polyethylene (PEX-AL-HDPE)	ASTM F1986
Fittings for cross-linked polyethylene (PEX)	ASSE 1061, ASTM F877; ASTM F 1807; ASTM F1960; ASTM F2080; ASTM F2098, ASTM F2159; ASTM F2434; ASTM F2735; CSA B137.5
Fittings for polyethylene of raised temperature (PE-RT)	ASTM F1807; ASTM F2098; ASTM F2159; ASTM F2735; ASTM F2769, ASTM D3261,

	CSA B137.18
Gray iron and ductile iron	ASTM F1476; ASTM F1548; AWWA C110/A21.10; AWWA C153/A21.53;
Insert fittings for polyethylene /aluminum /polyethylene (PE-AL-PE) and cross-linked polyethylene /aluminum /cross-linked polyethylene (PEX-AL-PEX)	ASTM F1974; CSA B137.10M
Malleable iron	ASME B16.3
Metal insert fittings for Polyethylene /aluminum /polyethylene (PE-AL-PE) and cross-linked polyethylene /aluminum /cross-linked polyethylene (PEX-AL-PEX)	ASTM F1974, CSA B137.10
Polyethylene (PE)	ASTM D2609; ASTM D2683; ASTM D3261; ASTM F1055; CSA B137.1, AWWA C901, AWWA C906
Polypropylene (PP)	ASTM F2389; CSA B137.11
Polyvinyl chloride (PVC)	ASTM D2464; ASTM D2466; ASTM D2467; CSA B137.2; CSA B137.3; ASTM D2665; ASTM F1866, AWWA C900, AWWA C905, AWWA C907
Oriented Polyvinyl Chloride (PVCO)	ASTM D2464; ASTM D2466; ASTM D2467; CSA B137.2; CSA B137.3; ASTM D2665; ASTM F1866, AWWA C900, AWWA C905, AWWA C907
Stainless steel	ASTM A312; ASTM A778; ASTM F1476; ASTM F1548; ASME A112.3.1
Steel	ASME B16.5; ASME B16.9; ASME B16.11; ASME B16.28; ASTM A53; ASTM A106; ASTM A234; ASTM A395; ASTM A420; ASTM A536; ASTM F1476; ASTM F1548
Solvent Cements	ASTM F493; ASTM D2564; ASTM F656; ASTM D2235
Solder	ASTM B32

5.3 | DESCRIPTION OF PRODUCT

An EPD developed using these PCR shall provide a narrative description of the product (the piping system) that will enable the user to clearly and unambiguously identify the product. This description shall include, where relevant:

- Product identification by common name, material type, and simple visual representation, which are permitted to be by photograph or graphic illustration;
- Product identificationby common name and ASTM or other standard designation if one exists for generic products, including the manufacturer's name for specific products;
- A description shall include a picture or a technical figure showing the main product characteristics;
- Range of water and effluent chemistries for which the product is recommended and its impact on service life;
- List of the standards and other product specifications to which the products comply;
- Details regarding reinforcement, thicknesses and colors;
- Flow diagram illustrating main unit processes by life-cycle stage according to the scope of the declaration;
- Materials and substances to be declared; and
- Any additional information that will assist in identifying the product.

Material contents of the finished product, including packaging, shall be declared in terms of the main components. Intentionally added substances officially classified as hazardous according to relevant North American regulations shall be stated. Product specific data that are confidential because of the competitive business environment, intellectual property rights, or similar legal restrictions, need not be declared, except where such data involve regulated hazardous substances, which must always be disclosed.

The following information, (see Table 4) shall be provided for all construction products to specify the end-of-life scenarios used for packaging or to support development of the end-of-life scenarios for packaging at the construction works level where the module is not declared.

Scenarios shall only model processes, for example recycling systems that have been proven to be economically and technically viable.

Table 4 — A5 product packaging waste

Module	**Parameter**	**Unit** (expressed per functional unit or per declared unit)	**Value**
A5	Mass of	kg or other	

Installation of the product	packaging waste Specify by type	unit as appropriate	
A5 Installation of the product	GWP based in biogenic carbon content of packaging, specify by type, (where relevant)	kg CO_2e	

6.0 Requirements for the Underlying LCA

The underlying LCA shall be conducted in accordance with ISO 14040 and ISO 14044.

6.1 | FUNCTIONAL AND DECLARED UNIT

Functional Unit

The **functional unit** of a product provides the quantitative normalization for comparing products of equivalent function or specification. A functional unit is defined for EPDs covering the complete cradle-to-grave life cycle or the cradle-to-gate life cycle with a use stage scenario.

The functional unit for these PCR shall consist of one or more of the following:

- A representative quantity of pipes, fittings and other materials required for 1,000 square feet of the flexible or rigid piping systems in three representative North American residential dwellings. The piping system requirements of a typical dwelling is provided in this PCR and is based on the average of the three scenarios assessed in PPFA's *Peer Reviewed Life Cycle Inventory for the Production and Use of Installed Residential Piping Systems for Three House Layouts*, undertaken by Franklin Associates in 2011, normalized to 1,000 square feet of building area, including:
    - a one-story 1,367 square foot house;
    - a two-story 2,811 square foot house; and
    - a two-story 4,402 square foot house.

    Tables A1 and A2 show the raw data from the three models used in the Franklin LCI. For other applications (other than residential dwellings), similar tables shall be developed and documented in the EPD; and/or

- 1,000 linear feet of flexible or rigid piping, which includes a representative number of fittings for use in buildings as determined by *Table A3*.

For evaluating hot water distribution systems, the HWSim program shall be utilized to draw a schedule for clustered use and cold start patterns as defined by PPFA's *Peer Reviewed Life Cycle Inventory for the Production and Use of Installed Residential Piping Systems for Three House Layouts*, undertaken by Franklin Associates in 2011.

An explanation of the selected functional unit shall be clearly given, covering the reference service life, installation methods and all ancillary materials such as fittings and solvent cement. The reference service life shall refer to the declared technical and functional quality of the product in the building. It shall be established in accordance with the ISO 15686-1, -2, -7, and -8 standards.

A weighted average thickness, or other applicable aspects of the product, shall be stated when the EPD deals with a generic or representative product group for a specific piping system scenario. The weights shall reflect the relative production volumes for the relevant piping solutions.

The lifetime of piping systems is determined by its specific application in the building and the building's service life. The assumed building life is specified in these PCR as 50 years. Therefore, the reference service life to be used for piping systems in North America is specified as the lifetime of the building, unless tests demonstrate that lifetime will be less than this. The lifetime of the piping system shall be determined under different water conditions, as lifetime for some products has been shown to be linked to water/fluid composition. Where tests or regional history demonstrate that the lifetime of the piping systems is less than 50 years, for example due to water chemistry, impact of replacement of the piping system shall be determined in the EPD.

In cases where several similar products are produced by a company, these PCR offer the possibility for similar products to be grouped as an average product in the same EPD provided that the difference between their environmental impacts is less than 10% for each environmental impact category. In cases where the difference is greater than 5%, it is still possible to include average products in the same EPD (e.g. in separate columns in a table). If a single value is chosen for each impact category for all products, the value reported shall be the worst performance within the range of variation. It is also permissible to show weighted 'averaged data' in an EPD as supplementary information if relevant.

Declared Unit

A **declared unit** is defined for EPDs covering only the cradle-to-gate or cradle-to-gate plus end-of-life stages. If the intended use of the EPD is for comparison purposes between different building products, the entire cradle-to-grave life cycle shall be included. In such situations, a functional unit shall be used rather than a declared unit.

Since in a cradle-to-gate model, there is no installation or use phase to consider, the declared unit is based on 1,000 linear feet of piping.

6.2 | SYSTEM BOUNDARIES

Figure 1 shows the life cycle stages and individual modules that shall be included within the LCA system boundary, depending on whether the EPD is cradle-to-gate or cradle-to-grave.

Figure 1: Life Cycle Stages and Modules

PRODUCT STAGE			CONSTRUCTION PROCESS STAGE		USE STAGE							END-OF-LIFE STAGE				OPTIONAL SUPPLEMENTARY
Raw material supply	Transport	Manufacturing	Transport	Construction-installation process	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-construction demolition	Transport	Waste Processing	Disposal	Potential net benefits from reuse, recycling and/or energy recovery beyond the system boundary
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4 err	D

Cradle-to-Gate (B2B EPDs) | The life cycle activities and related processes shall include modules A1, A2, and A3—the product stage—as defined below, with scenarios for other life cycle stages as appropriate.

Cradle-to-Grave (mandatory for B2C EPDs) | A complete cradle-to-grave LCA shall be developed for the product, including all life cycle stages and modules, for a specified defined function and service life, inclusive of maintenance and replacement and end-of-life effects.

Optional Supplementary | Information beyond the system boundary.

Any site-generated energy and purchased electricity shall be included in the system boundary. The extraction, processing and delivery of purchased primary fuels, for example natural gas and primary fuels used to generate purchased electricity, shall also be included within the boundaries of the system. Regionally-specific inventory data on electricity shall be based on subnational North American consumption mixes that account for power trade between the regions.

If such regional data are not available, production mixes of the three continental interconnections (East, West, Texas), as well as those of Hawaii and Alaska are permitted to be used. In the case of a B2C EPD, the North American average grid mix shall be used for the construction and use stages if the use location is not known. A comparable approach shall be taken for electricity consumption in the case of materials or input

products imported from outside of North America. The sources for electricity (calculation procedure, national energy mix for example) shall be documented.

Modules A1-A3, the Product Stage:

- Extraction and processing of raw materials, including fuels used in extraction and transport within the process;
- Transportation of processed raw materials to manufacturing site;
- Conversion of processed raw materials to piping base material;
- Conversion of processed raw materials to fittings base material;
- Production of packaging for delivery of piping and fittings base material to fabrication site;
- Transportation of piping and fittings base material and other materials to fabrication site;
- Conversion of base material to piping and fittings;
- Production of fuels and electricity consumed for production of the piping system; and
- Production and disposal of materials and chemicals consumed for production of the piping system.

Module A1, A2 and A3 are permitted to be declared as one aggregated module A1-A3.

Modules A4-A5, the Construction Stage:

- Production of packaging for delivery of piping and fittings to distribution center;
- Transportation of piping and fittings to distribution center;
- Storage of piping and fittings at distribution center;
- Transportation of piping and fittings to retail/ supplier;
- Storage of piping and fittings at retail/ supplier;
- Transportation of piping and fittings to the installation site;
- Installation of piping system, including piping, fittings and materials/energy required for installation, at installation site;
- Production of fuels and electricity consumed for installation of the piping system; and
- Production and disposal of materials and chemicals consumed for installation of the piping system, including cutting waste.

Modules A4 and A5 are permitted to be declared as one aggregated module A4-A5.

In the case of EPDs based on this PCR, the time of installation (e.g. labor hours) shall be included. Sustenance for workers (i.e. food etc.) and impacts of manual labor shall be excluded.

Modules B1-B7, the Use Stage

Modules B1-B7 are treated as a typical scenario, which shall be described in detail as follows.

- Reference service life of the building shall be assumed to be 50 years and the maintenance regime and number of replacements of the piping system shall be declared accordingly (note that an assumed 50-year reference service life for the building is an accepted time period for the purpose of comparative analysis).
- Include any maintenance/replacement of the piping system required to attain the reference service life of the building.
- Maintenance/replacements are to be modeled according to manufacturers' guidelines regarding the reference service life of the piping system, which must be based on a verifiable product performance history.
- When the product reference service life is less than the assumed building service life (50 years), the aggregated product stage, construction process stage and end-of-life stage impacts (modules A1–A5 and C1–C4) associated with the number of changeovers necessary to equal the service life of the building shall be included. When the product service life is greater than the building service life, the initial production impacts shall be fully calculated and shall not be discounted to reflect the remaining product service life.
- When the reference service life of a piping system is less than the assumed building service life (50 years), the number of replacements that will be necessary to fulfill the required performance and functionality over the building service life shall be identified. The combined impacts of the original product and any replacements shall be determined by dividing the building service life by the service life of the product, and the impacts multiplied by the result. For example, if the expected service life of a component is 25 years, the impacts would be multiplied by 2 (i.e. 50 years/25 years), thus normalizing the changeovers to be equivalent to the assumed 50-year building service life.
- Production of fuels and electricity consumed for operation or use of the piping system shall be included. This includes energy used for water heating, where applicable.

- Production and disposal of materials and chemicals consumed for operation or use of the piping system.
- Water and energy usage (including production and distribution) required for cleaning, as part of maintenance shall be included in this module (B2), and not in modules B6 and B7.
- The boundary of the module "Energy use to operate integrated technical systems" shall include:

  B6 Generation, distribution and use of energy during the operation of the product (the integrated technical system), together with its associated environmental aspects and impacts including processing and transportation of any waste arising on site from the use energy.
- If relevant for the product group, aspects related to the production of integrated technical systems equipment shall be assigned to Modules A1-A3; e.g. radiators, boiler, ventilation system.
- Aspects related to transportation and installation of integrated technical systems equipment shall be assigned to Modules A4-A5.
- Energy use and other impacts during maintenance, repair, replacement or refurbishment activities for the equipment shall be assigned to Modules B2-B5.
- Aspects related to the waste processing and final disposal of equipment shall be assigned to Modules C1-C4.The boundary of the module 'operational water use by integrated technical systems' shall include:

  B7 Water use during the operation of the product (the integrated technical system), together with its associated environmental aspects and impacts considering the life cycle of water including production and transportation and waste water treatment.
- For Hot and Cold Water Distribution (HCWD) pipes, heat loss and wasted water from the use performance of domestic hot water distribution systems shall be included in a use scenario. This should be evidence-based and calculated in a consistent manner.
- The evaluation of heat loss shall be based on the thermal properties of the pipe materials and the temperature differential between 130°F water in the pipes and surroundings a constant temperature of 60°F. The use phase shall be based on a 4-person household using 39.7 gallons of heated (or hot) water per day per person. The evaluation of heat loss and wasted water shall use the HWSim model developed by Davis Energy Group available at https://frontierenergy.com/ and described in PPFA's Peer Reviewed Life Cycle Inventory for the Production and Use of Installed Residential Piping Systems for Three House Layouts. In order to account for the

effect of use patterns, the following two use patterns shall be evaluated and the results separately reported:

- A **clustered** use pattern, where the majority of weekday water use takes place in the mornings and evenings (assuming the residents are at work or school for the majority of the day); and
- A **cold start** use pattern, where water use is spread throughout the day.

Modules B1 through B7 are permitted to be declared as one aggregated module B1-B7.

Modules C1-C4, the End-of-Life Stage

Modules C1-C4 are treated as a typical scenario, which shall be described in detail as follows.

- Removal of piping system at end of useful life;
- Transportation of removed piping system at end-of-life to waste treatment location;
- Waste management of piping system at end-of-life (landfill, incineration or recycling); and
- Production of fuels and electricity consumed by waste management processes.
- If there are, for example three different recovery and disposal options, the most commonly used one, or all three scenarios, shall be declared separately
- Energy recovery shall be based on existing technology and current practice.
- A scenario based on a typical end-of-life, for example, a mix of recovery and disposal options based on a national situation shall only be provided if the scenarios for the separate individual options are also provided.
- Waste processing shall be modelled and the elementary flows shall be included in the inventory.
- When materials have reached the system boundary between product systems, they may be considered as materials for energy recovery provided the energy recovery process has an energy efficiency rate higher than 60 %.
- Processes where energy is recovered from waste with an efficiency rate below 60% shall be considered as disposal processes and modelled in C4.
- Waste processing shall be considered as part of the product system under study. In the case of materials leaving the system as secondary materials or fuels, processes such as collection and transport before the system boundary between product systems are part of the waste processing of the system under study. However, after having reached the system boundary between product systems, further processing may be necessary in order to replace primary material or fuel input in

another product system. Such processes are considered to be beyond the system boundary but may be considered in optional module D.

- The process of energy recovery from landfill gas shall be considered as part of the disposal process in C4. Loads and benefits of the recovered energy may be considered in optional module D.
- Loads, (e.g. emissions) from all end-of-life information modules (C1-C4) shall be considered part of the product system under study, according to the "polluter pays principle". The loads associated with the use of secondary fuels shall always be part of the product system using the secondary fuel.
- The inventory for the end-of-life stage includes all unit operations for the discarded construction product until it is determined to have crossed the system boundary between product systems and becomes a usable material flow for reuse, energy recovery and/or recycling.
- If the discarded product does not cross the system boundary, it is considered as waste, and all waste treatment processes including those of disposal shall be assigned to the product system under study.

Module C1, C2, C3 and C4 are permitted to be declared as one aggregated module C1-C4.

Module D, optional supplementary information beyond the system boundary

Modules D1-D4 are treated as a typical scenario, which shall be described in detail as follows.

- The information in module D may contain qualitative technical information as well as the quantified predetermined LCA-derived parameters. The LCA results from module D shall always be reported separately.
- If module D includes the result from an LCA, the following shall be applied:
- The potential environmental loads and benefits of the net output flow are calculated by:
    - identifying the point of substituted functional equivalence where the secondary material or fuel or recovered energy substitutes primary production;
    - adding the loads associated with any further processing occurring beyond the system boundary which is required to reach the point of substituted functional equivalence;
    - subtracting the impacts resulting from the substituted production of the product or generation of the energy, and;
    - applying a justified correction factor to reflect the difference in functional equivalence where the processed net output flow does not reach the functional equivalence of the substituting process.
    - In the case of recovered energy, the average production mix shall be substituted, e.g. national average LCI for grid electricity or district heating. In

cases where the substituted production primary process is not clear, as a conservative approach, the typical production mix, rather than primary product should be substituted so that the benefit of recovery is not overstated. This is usually the case for electricity and heat generation.

- The EPD is developed for construction products and will be part of a construction works that in reality will affect the recyclability potential. Even though module D deals with the future (e.g. after end-of-life of the construction product or the construction works), current practice shall be used for the scenario setting in order to achieve a verifiable result. If today's average is not available for the quantification of potential benefits or avoided loads, a conservative approach shall be used.

Additional Assumptions

All assumptions from the LCA shall be described in detail.

LCA results for the production, installation, use and end-of-life stages shall be declared separately in the EPD.

Any transportation data other than that identified above shall also be included and based on actual information or documented assumptions if no data exists.

The end-of-life scenario shall be based on current waste management and recycling practices for construction wastes that are relevant to the market that the EPD is intended for. Information shall be provided relating to how the piping system is collected at end-of-life, waste management practices and any other assumptions relevant to the scenario (e.g. transportation). Data sources for waste management practices shall be documented and shall be based on state/province-wide or national statistics, whichever are more appropriate.

Summary of EPD Types and Related Requirements

Error! Reference source not found.Error! Reference source not found. summarizes the unit and reference service life requirements by life cycle stage and related modules.

Table 5: Unit and Reference Service Life Requirements

EPD Type	Life Cycle Stages and Modules	Declared Unit (DU) or Functional Unit (FU)	Reference Service Life (RSL)	Primary Audience
Cradle to shipping gate	Product stage; modules A1 to A3	DU	Not specified	B2B

EPD Type	Life Cycle Stages and Modules	Declared Unit (DU) or Functional Unit (FU)	Reference Service Life (RSL)	Primary Audience
Cradle to building	Product and construction stages; modules A1 to A5	DU	Not specified	B2B
Cradle to building- with end-of-life stage	Product, construction and end-of-life stages; modules A1 to A5 and C1 to C4	DU	Not specified	B2B
Cradle to building- with use stage	Product, construction and use stages; modules A1 to A5 and B1 to B5	FU	RSL is required	B2B
Cradle to grave	Product, construction, use and EOL stages; modules A1 to C4	FU	RSL is required	B2B and/or B2C

Excluded from System Boundary

A summary of items that are permitted to be excluded in the primary product stages include:

- Production, manufacture and construction of manufacturing capital goods and infrastructure;
- Production and manufacture of production equipment, delivery vehicles and laboratory equipment;
- Personnel-related activities (travel, furniture, and office supplies); and
- Energy and water use related to company management and sales activities that are permitted to be located either within the factory site or at another location.

7.0 Life Cycle Inventory Analysis

7.1 | DATA COLLECTION AND DESCRIPTION OF DATA

The data shall be representative according to temporal, geographical, and technological requirements.

- Temporal - The information obtained from the manufacturing process shall represent annual values, preferably from the previous twelve-month period or calendar year, unless accompanied by a statement attesting to the validity of the older data. Average background data shall not be older than ten years, unless accompanied by a statement attesting to the validity of older data.

- Geographical - The geographic region of the relevant life cycle stages included in the calculation of representative data shall be documented.
- Technological - Data shall represent technology in use.

The following specific or generic background data shall be documented with regard to data sources:

- Extraction and/or production of raw materials (specific or average background);
- Manufacturing of the product (specific);
- The fuel mix and calculation procedures for electricity generation;
- Hazardous waste according to applicable federal or state/provincial regulations (or appropriate regulations for materials imported outside North America);
- Proxies for upstream products where specific or generic data is not available; and
- Weighted averages based on volume or mass used to assign transport distance and mode if multiple suppliers are used for one material.

Primary (specific) data relating to the life cycle of the product is preferred for life cycle assessment (LCA) calculations and required for the life cycle stages under the operational control of organization(s) preparing the EPD. Life cycle inventory (LCI) data relating to plastic plumbing pipes is available in PPFA's *Peer Reviewed Life Cycle Inventory for the Production and Use of Installed Residential Piping Systems for Three House Layouts*, undertaken by Franklin Associates in 2011. Where specific data are not available, PPFA's LCI should be referred to in the first instance as a data source when assessing plastic piping in residential buildings.

For generic data, national databases shall be used to the extent that they are applicable (for example, U.S. Life Cycle Inventory Database, www.nrel.gov/lci; and the National Institute for Standards and Technology (NIST) Building for Environmental and Economic Sustainability (BEES) database, www.nist.gov/el/economics/BEESSoftware.cfm). If appropriate national data are not available, sources for similar technology adjusted for national boundary conditions (for example, energy mix) are permitted to be used. Data from other regions are acceptable if it is determined and justified that those data are the best available.

All data sources shall be specified and referenced, including database name and year of publication. Sources of data for transport models (including transport mode, distances, and quantities to be transported) and energy production shall be documented. Where proxy data are used in the absence of specific data for chemicals or other inputs, the source and justification for selection of the proxies shall be documented in the LCA report.

When preparing an average EPD for an identical product manufactured at multiple facilities, the LCI data for each site shall be weighted to determine the average. Weighting shall be by annual product production. Data reported in the declarations shall be as production-weighted averages of multiple facilities.

The product content shall be described in the declaration. Product-specific data that are confidential because of the competitive business environment, intellectual property rights, or similar legal restrictions need not be declared. In such cases, a notation that the information is confidential shall be made along with a description of the function of the component. The exception is where product-specific data involve regulated hazardous substances, which must always be disclosed.

In the case of B2C EPDs, the amount of material used as input to enable the product to meet the functional unit requirements shall include related accessories and other materials (i.e. ancillary materials) unless the reason for the omission of these is explained.

7.2 | CUT-OFF RULES

Criteria for the exclusion of inputs and outputs (cut-off rules) in the LCA and information modules and any additional information are intended to support an efficient calculation procedure. They shall not be applied in order to hide data. All inputs and outputs of a unit process for which data are reasonably available shall be included in the calculation. Any application of the criteria for the exclusion of inputs and outputs shall be documented. Data gaps shall be permitted to be filled by conservative assumptions with average or generic data. Any assumptions for such choices shall be clearly documented.

If data are not reasonably available, the cut-off criteria for flows to be considered within the system boundary are as follows.

- Mass - If a flow is less than 1% of the cumulative mass of the unit processes, it is permitted to be excluded, provided its environmental relevance is minor.
- Energy (renewable and non-renewable) - If a flow is less than 1% of the cumulative energy of the system model, it is permitted to be excluded, provided its environmental relevance is minor.
- Environmental Impacts – If a flow is less than 1% of the cumulative environmental impact of the system model, it is permitted to be excluded, provided its environmental relevance is minor.
- Environmental relevance - Material and energy flows known or expected to have the potential to cause environmental relevant emissions into air, water, or soil related to the environmental indicators of these PCR shall be included unless justification for exclusion is documented.

At least 95% of the energy usage and mass flow shall be included and the life-cycle impact data shall contain at least 95% of all elemental flows that contribute to each of the declared category indicators.

All hazardous and toxic materials and substances, as defined by relevant North Amercian regulation, shall be included in the inventory and the cut-off rules shall not apply to such substances.

7.3 | DATA QUALITY REQUIREMENTS

Primary (specific) data relating to the life cycle of the product is preferred for life cycle assessment (LCA) calculations and required for the life cycle stages under the operational control of organization(s) preparing the EPD.

Any secondary data source used in the underlying LCI shall be complete and representative of the applicable North American region in terms of its geographic and technological coverage and of a recent vintage, which is typically less than ten years old. Any deviations from these requirements for secondary data shall be documented, and the following shall apply.

- All data shall be accurate and representative of the production process, current technology, and current measurement capability;
- The information obtained from the manufacturing process shall be annual average values;
- Average background data shall not be older than ten years for industry average data or five years for producer-specific data, unless justification is provided;
- When the owner of the EPD is not the owner of all upstream processes, the owner shall contact its suppliers within the system boundary. If the suppliers do not supply data, the owner shall use the best available data based on data quality requirements of this PCR; and
- Data shall be identified as direct (for example, measurements or purchasing records), indirect (based on calculations), estimated, or assumed.

7.4 | UNITS

SI units shall be used with conversions as shown in the table below as necessary. Preferred power and energy units are as follows:

- kWh or MJ for electric energy; and
- kW or MW for power.

Table 8: Conversion Factors to be Used if Reporting in IP Units (Imperial)

CONVERT FROM	TO	MULTIPLY BY
Square meter (m^2)	Square foot (sq ft)	1.076391E+01
Kilogram (kg)	Pound (lb)	2.204622
Mega joule (MJ)	British Thermal Unit (Btu)	9.478170E+02
Degree Celsius (°C)	Degree Fahrenheit (°F)	(°C * 9/5) +32
Cubic meter (m^3)	Cubic foot (ft^3)	3.531466E+01
Meter (m)	Foot (ft)	3.281
m^2K/W	ft^2Fhr/Btu	5.6783
Metric tonne	Ton	1.102

Source: NIST: http://physics.nist.gov/Pubs/SP811/appenB9.html; http://www.nist.gov/pml/wmd/metric/temp.cfm; and http://www.nist.gov/pml/wmd/metric/common-conversion-b.cfm

7.5 | ALLOCATION RULES

In a production process in which more than one type of product is generated, it is necessary to allocate the environmental flows (inputs and outputs) from the process to the different products to get product-based inventory data. Allocation, if required, shall follow the requirements and guidance of ISO 14044, Section 4.3.4.

If product input materials include recycled or recovered materials, these shall be considered raw materials. Only the materials, water, energy, emissions, and other elemental flows associated with transport to reprocessing (including handling, sorting, and transportation) need to be included. Any activities before transport to reprocessing shall be allocated to the original product. Recycled and recovered materials used as fuels shall be considered alternative energy.

Energy content of feedstocks used to produce materials (for example, plastic) shall be captured in material resources (kg), while process energy shall be recorded in energy resources (MJ).

Allocation related to transport shall be based on the mass of transported product.

When a product's original function is no longer needed or possible, the product shall be permitted to be processed further in a waste management system. For example, it is permitted to be recycled, reused, or energy recovered. Emissions from downstream recycling or combustion state shall be allocated to the new downstream products, such as heat and electricity. In the case of incineration of wastes for energy production at the

primary production site, the combustion emissions shall be allocated to the product, unless the energy is exported.

Recycling processes shall be treated as closed loop recycling, as long as no change occurs in the inherent properties of the recycled material. In such cases, the need for allocation is avoided since the use of secondary material displaces the use of virgin (primary) materials.

If different allocation options are relevant and a deviation of greater than 20% is a foreseen outcome, a sensitivity analysis shall be initiated. These different allocation approaches and data sets shall be documented and declared.

The setting of the system boundary for the product system shall follow two principles:

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

Co-products from unit processes leaving the system at the production stage (A1-A3) shall be allocated in accordance with ISO 21930 Section 7.2.3.3. Loads and benefits from allocated co-products shall not be declared in module D (see ISO 21930 Section 7.1.7.6).

The output of waste during this life cycle stage may become a useable output flow, such as a secondary material/fuel or recovered energy, when it has been through a recovery process and complies with the conditions described in the system boundary between product systems (see ISO 21930 Section 7.1.6).

These useable output flows shall not be considered as co-products but shall be considered waste and no allocation to secondary material, secondary fuels or recovered energy shall be permitted. As an option, the potential loads and benefits from the net useable output flows from recovery processes may be considered as supplementary information in module D.

To support the development of the end-of-life scenarios for packaging at the construction works level where the information module A5 is not declared, data shall be provided about any packaging used for the product as specified in 7.1.7.3.For the purposes of this document, any approach to assigning impacts to co-products, whether by allocation or by avoiding allocation, shall be considered as allocation and shall follow the principles for allocation set out in this document.

It shall not be used so as to avoid the allocation of impacts to any co-products that are either produced or used in the manufacture of construction products.

It may be used when system expansion leads to a conservative result for any products subsequently used in any construction works.

If there is a need to calculate impact data for both products and co-products, system expansion (the approach of expanding the product system to include the additional functions related to the co-products) is not considered as an option for avoiding allocation within EPD studies. It shall not be used to avoid the allocation of impacts to any co-products which are produced or used in the manufacture of construction products. It can be used when system expansion leads to a conservative result for any products subsequently used in any construction works.

The LCA study shall first identify any unit process that produce more than one product, then determine whether it is possible to divide the unit process into one or more sub-processes that each have a single output. Then separate input and output data related to these individual sub-processes can be collected.

Avoiding allocation by subdivision is suitable for unit processes with co-products whose manufacture is not intrinsically linked. This may occur, for instance, when data collection is performed at a given location without going deeper into detail regarding specific processes occurring at that site, for example separate production lines or sequential manufacture of products. For these types of processes, the ratio between the co-products could be significantly altered or only one co-product produced, when required. In such cases, sub-division shall not be used and the co-product allocation procedure given above should be used. If a unit process is suitable for sub-division, but the required data are not available, the inputs and outputs of the unit process under study should be segregated into its different products or functions in a way which reflects the underlying physical relationships between them; i.e. they shall reflect the way in which the inputs and outputs are changed by quantitative changes in the products or functions delivered by the system Such segregation shall be described and justified in the project report.

When co-products or secondary flows crossing the system boundary are considered in any EPD study, the following principles shall be followed:

- The inputs and outputs shall be allocated to the different products according to clearly stated procedures that shall be documented and explained together with the allocation procedure.
- 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.
- Irrespective of the allocation approach chosen for a co-production process or for secondary flows crossing the system boundary between product systems, specific inherent properties of such co-products or flows, e.g. calorific content, composition (biogenic carbon content, CaO/Ca(OH)2 content etc.) shall not be allocated but always reflect the physical flows.

- Allocation to co-products shall respect the main purpose of the processes studied, allocating all relevant products and functions appropriately. The purpose of a plant and therefore of the related processes is generally declared in its permit and shall be taken into account. Where the revenue from a process is a significant reason for its existence, the proportion of revenue associated with each co-product should be broadly reflected in whichever allocation approach is used for co-products. This is to avoid disproportionate allocation of impacts to co-products.
- In situations where it is unclear if an output is a co-product, by-product or a waste, a conservative approach of allocating burdens to the primary product system under consideration shall be used. The final disposal of wastes is included in the system boundary of the process which generated them.
- Consistent allocation procedures shall be uniformly applied to similar inputs and outputs of the system under consideration. For example, the approaches of allocation to co-products or to secondary materials crossing the boundary between product systems, should use the same procedure used for co-products or to secondary material flows entering the product system.
- Impacts from allocated co-products shall not be included in module D.

A conservative approach may be used for the assessment of the primary product by not allocating any environmental flows to a co-product and retaining all impacts within the primary product system.

Where a co-product is a relevant input, then the allocation procedure shall be followed to understand the impacts that are allocated from the joint co-production process to the co-product.

The use of upstream data which do not respect the allocation principles described in this document shall be;

- clearly identified;
- subjected to a sensitivity analysis conducted and documented so as to illustrate the likely influence on the results with the upstream data used;
- justified in the project report, and
- as a minimum, be in line with ISO 14044 allocation rules and attributional LCA.

8.0 Impact Categories and Characterization Factors

Environmental impact category indicators shall be taken from *Table* 9 for declaring environmental aspects in accordance with ISO 21930:2017, Section 9.5 and ISO 14044.

ISO 14046 will be referenced when dealing with water consumption.

Table 9: Declaration of Environmental Category Indicator Results, Use of Resources, and Generation of Waste

CATEGORY INDICATOR	UNIT
Global warming potential (GWP)	kg CO_2 equivalent
Acidification potential	kg SO_2 equivalent
Eutrophication potential	kg N equivalent
Smog creation potential	kg NMVOC equivalent
Ozone depletion potential	kg CFC-11 equivalent
Total primary energy consumption	
Nonrenewable fossil	MJ (LHV)
Nonrenewable nuclear	MJ (LHV)
Renewable (solar, wind, hydroelectric, and geothermal)	MJ (LHV)
Renewable (biomass)	MJ (LHV)
Material resources consumption	
Nonrenewable material resources	kg
Renewable material resources	kg
Net fresh water (inputs minus outputs)	l
Non-hazardous waste generated	kg
Hazardous waste generated	kg
Renewable primary resources used as an energy carrier (fuel)	
Biobased materials used as an energy source (Hydropower, solar and wind power)	MJ (LHV)
Renewable primary resources with energy content used as material	
Biobased materials used as materials (wood, hemp, etc…)	kg
Non-renewable primary resources used as an energy carrier (fuel)	
Nonrenewable material as an energy resource (oil, gas and coal)	kg
Non-renewable primary resources with energy content used	

as materials	
Nonrenewable material used for products	kg
Secondary materials	
Materials recycled from previous use or waste.	kg

Notes for Table 9:

1. Fresh water is naturally occurring water on the earth's surface and underground as groundwater in aquifers and underground streams. The term specifically excludes seawater and brackish water, but does include fresh water that has been treated to make it potable. Energy use and other impacts associated with fresh water treatment are not included.

2. Recovered or recycled materials are neither nonrenewable nor renewable resources under ISO definitions. The use of such materials shall be permitted to be reported as additional environmental information as per Section 9.

3. Primary energy is an energy form found in nature that has not been subjected to any conversion or transformation process. Examples of primary fuels are coal, natural gas and biomass.

4. Recycled and recovered materials with fuel content and used as fuels shall be considered alternative energy. Examples of such secondary fuels are solvents, wood, tires and animal fat. Emissions from secondary fuels shall be included in the calculation of the relevant environmental impacts.

5. Energy consumption shall be reported in Lower Heating Values (LHV) mega joules.

6. Where applicable, feedstock energy shall be declared and shown separately.

7. The abiotic depletion potential – (ADPfossil) – shall be reported. It includes all fossil resource indicators (e.g. coal, oil, fossil gas) used as energy and material.

The impact categories of life cycle impact assessment (LCIA) shall be calculated using characterization factors specified in version 2.1 of TRACI (Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts).

https://www.epa.gov/chemical-research/tool-reduction-and-assessment-chemicals-and-other-environmental-impacts-traci

ISO 21930 will be referred when calculating the impacts of biogenic carbon, land use change, and carbonation.

The following output flow categories shall be declared and specified for all information modules included in the EPD:

- components for reuse;
- materials for recycling, i.e. secondary material used in the next product system;
- materials for energy recovery, i.e. secondary fuels used in the next product system;
- recovered energy exported from the system.

Output flows from other information modules shall be assigned to the information modules where they occur.

9.0 Additional Environmental Information

An EPD shall include additional information such as given in the points below, related to environmental issues, other than the environmental information derived from LCA, LCI or information modules. This information shall be separated from the information described in ISO 21930 Section 8.3 and ISO 14025, Sections 7.2.2 and 7.2.3. Identification of the significant environmental aspects shall, as a minimum, take into consideration the following:

- Information on issues, such as:
    - Geographical aspects relating to the declared environmental impacts at any stages of the life cycle;
    - Environemental responsible sourcing;
    - Best environmental practice;
    - Energy use for operating pollution control systems;
    - Toxicity risks or hazards related to human health and/or the environment.
- Data on building product performance if environmentally significant;
- Organization's adherence to any environmental management system, with a statement on where an interested party can find details of the system;
- Any other environmental certification program applied to the building product and a statement on where an interested party can find details of the certification program;
- Other environmental activities of the organization, such as participation in recycling or recovery programs or renewable energy credits (REC), provided details of these programs are readily available to the purchaser or user and contact information is provided;
- Information that is derived from LCA but not communicated in the typical LCI- or LCIA-based formats;
- Instructions and limits for efficient use;
- If a manufacturer wishes to declare quantitative or qualitative information on delayed emissions within the EPD, the information shall be reported under 'Additional environmental information not derived from LCA', (see clause 9.6) and the underlying methodology shall be referenced.
- Hazard and risk assessment on human health and the environment;

- Information on absence or level of presence of a material in the product that is considered of environmental significance in certain areas (see ISO 14021:1999, 5.4 and 5.7);
- Preferred waste management option for used building products; and
- Potential for incidents that can have impact(s) on the environment, such as:
  - the end-of-life stage, from deconstruction, reuse, demolition, recycling and disposal;
  - energy, water-saving etc. and other improvements, such as acoustical improvements;
  - energy content of the building product for energy recovery in the end of life;
  - recycled content or recycling rates.
- In addition to those specified in *Table 8*, the following environmental impact category indicators shall be considered:
  - Ecotoxicity potential, measured in CTUe (Comparative Toxic Unit for Ecosystems);
  - Respiratory effects, measured in kg PM 2.5 equivalent;
  - Carcinogens, measured in CTUh (Comparative Toxic Unit for humans);
  - Non-carcinogens, measured in CTUh (Comparative Toxic Unit for humans);
  - Fossil fuel depletion, measured in MJ surplus; and
  - Land transformation[3], measured in kg deficit.

Additional information shall only be related to environmental issues. Information and instructions on product safety unrelated to the environmental performance of the building product shall not be part of a Type III environmental declaration.

An LCA should consider all significant aspects related to the product during its life cycle. Significant environmental aspects that are not covered by the LCA shall be reported in the EPD, where relevant, as additional environmental information. Such information may be either qualitative or quantitative information related to the product`s life cycle (see ISO 14025, 7.2.3) and shall be verifiable and comply with the requirements stated in ISO 14025, 7.2.4.

[3] Land transformation impacts shall be calculated according using the Soil Organic Matter (SOM) model as specified in the Product Environmental Footprint Guide (http://ec.europa.eu/environment/eussd/smgp/policy_footprint.htm) and using characterisation factors specified in the International Reference Life Cycle Database System (ILCD) (http://eplca.jrc.ec.europa.eu/?page_id=86).

An EPD based on these core rules may also address additional environmental information that is not part of the pre-set LCIA indicators. This may include impact categories that are still under development or have high levels of uncertainty that preclude international acceptance pending further development. Such potential LCIA categories shall follow the requirements for characterization models given in ISO 14044.

If such LCIA-type results are included in the EPD, the LCA report and the EPD shall include a written discussion of the results, including the limitations related to the LCIA-type methods used. This requirement also applies to the development of sub-category PCR.

The following indicators shall be included for transparency, and specified for all information modules, where the respective flows occur:

- uptake and emissions associated with biogenic carbon content of the bio-based product;
- emissions from calcination and uptake from carbonation;
- uptake and emissions associated with biogenic carbon content of the bio-based packaging.;
- emissions from combustion of waste from renewable sources used in production processes;
- emissions from combustion of waste from non-renewable sources used in production processes. Waste should be declared in the format provided in Table E.5 of ISO 21930. The same tabular format may be used in the EPD.

The output flows that have crossed the system boundary between product systems shall be declared as stated in Table 4 of ISO 21930 and specified for all information modules.

10.0 EPD Supporting Data

A project report shall be prepared in accordance with the requirements and guidance ofISO 14044, Section 6, for third-party reports. This information shall document the LCA study and additional environmental information in a systematic, comprehensive way, and shall be made available to the verifier in order to demonstrate that the requirements of this PCR document and ISO 21930 have been met. The project report shall include the following or state why there are any exclusions:

- The name of the organization that commissioned the report, the contact information of the report author, and the date of the report;
- The input and output environmental data of the unit processes that are used for the LCA calculations;
- Record that the LCA-based information and the additional information as declared in the EPD meet the requirements of this document;

- Data and information that is of importance to the data published in the EPD and shall meet the requirements of this document and any relevant sub-category PCR used for the EPD development;
- Special care shall be taken to demonstrate, in a transparent manner, how the data and information declared in the EPD were derived from the LCA study and how the RSL was established;
- Made available to the verifier with the requirements on confidentiality stated in ISO 14025:2006;
- laboratory results or measurements for the content declaration;
- laboratory results or measurement of functional or technical performance;
- documentation on declared technical information on life cycle stages that have not been considered in the LCA of the construction product and that will be used for the assessment of construction works (e.g. transport distances, RSL according to Annex A, energy consumption during use, cleaning cycles, etc.);
- laboratory results or measurements for the declaration of emissions to indoor air, soil and water during the product's use stage.
- The documentation (measurements, calculations, estimates, sources, correspondence, traceable references to origin, and so forth) that provides the basis from which the process data for the LCA is formulated;
- The specification used to create the manufacturer's products;
- Energy consumption figures;
- Emission data to air, water, and soil;
- Waste production;
- Data that demonstrates that the information is complete—in specific cases, reference shall be permitted to be made to, for instance, standards or quality regulations;
- Referenced literature and databases from which data have been extracted;
- Data used to carry out sensitivity analyses;
- Documentation that demonstrates that the building products fulfill the desired function(s) and performance;
- Documentation that demonstrates that the chosen processes and scenarios in the flow chart satisfy the requirements set in ISO 21930;
- Documentation that substantiates the chosen life cycle of the building products;
- Documentation and substantiation of the percentages or figures used for the calculations in the end-of-life stage;
- Documentation and substantiation of the percentages and figures (number of cycles, prices, and so forth) used for the calculations in the allocation procedure;

- Information showing how averages of different reporting locations have been calculated to obtain generic data;
- Documentation used to substantiate any qualitative information in the additional environmental information;
- Procedures used to carry out the data collection (questionnaires, instructions, informative material, confidentiality agreements, and so forth);
- Data quality assessment;
- The characterization factors used;
- The criteria and substantiation used to determine the system limits and the selection of input and output flows;
- Documentation that demonstrates consistency when using information modules; and
- Documentation used to substantiate the other choices and assumptions.

11.0 Content of the EPD

The following demonstration of verification shall be completed and included with the EPD. Third-party verification is optional for B2B EPDs, and is mandatory for B2C EPDs.

Demonstration of Verification

PCR REVIEW, WAS CONDUCTED BY: < Name and organization of the chair, and information on how to contact the chair through the program operator >
INDEPENDENT VERIFICATION OF THE DECLARATION AND DATA, ACCORDING TO ISO 14025: Internal External
(WHERE APPROPRIATE [4]) THIRD PARTY VERIFIER: <Name of third party verifier>

All Type III environmental declarations in a product category shall follow the format and include the parameters as identified in this PCR. The following general information shall be declared in the EPD:

[4] Optional for business-to-business communication, mandatory for business-to-consumer communication.

- Name and address of the manufacturer(s);
- Product identification by name (including, for example, production code) and a simple visual representation of the product;
- Description of the building product's use and the functional or declared unit of the product to which the data relates;
- Description of the application (installation) of the building product where relevant;
- Detailed list of the substances, by weight, that make up the building product, taking into account cutoff rules and confidentiality;
- Data from LCA or LCI or information modules, as per ISO 14025, Section 7.2.2;
- Additional environmental information (see Section 9);
- Statement of whether the EPD is cradle-to-gate or cradle-to-grave;
- Statement that EPDs from different programs (using different PCR) may not be comparable;
- Statement that the EPD represents an average performance in cases where an EPD declares an average performance for a number of products, and the range of the product's performance with respect to the stated average;
- Site(s), manufacturer or group of manufacturers, or those representing them, for whom the results of the LCA are representative;
- Information on where explanatory material is obtained;
- Description or diagram of the life cycle stages included in the LCA subdivided into production, construction, use and end-of-life stages, and system boundaries;
- When the EPD includes the use stage, a description of the nature of the processes and ancillary materials that are required for installing the building product in the building or other type of construction works and their replacement and maintenance according to the cutoff criteria;
- Name of the program and the program operator's address and, if relevant, the logo and website URL;
- Identification of the PCR document on which the EPD is based;
- Date the EPD was issued and period of validity;
- Site(s), manufacturer, or group of manufacturers or those representing them for whom the results of the LCA are representative;
- Name of PCR review panel chair;
- Whether the independent review of the EPD and data was conducted by an internal or external verifier (third-party verification is mandatory for B2C EPDs); and
- Name, address, phone number and e-mail of the third-party verifier and logo of the verification body, if applicable.

ISO 14025 9.2.2 states that, "Type III environmental product declarations intended for business-to-consumer communication shall be available to the consumer at the point of purchase."

12.0 References

ASTM Standards:[5]

CSA Standards:[6]

ISO Standards:[7]

ISO 6707-1: 014 Buildings and Civil Engineering Works — Vocabulary — Part 1: General Terms

ISO 14021:1999 Environmental Labels and Declarations — Self-declared Environmental Claims (Type II Environmental Labeling)

ISO 14025:2006 Environmental Labels and Declarations — Type III Environmental Declarations — Principles and Procedures

ISO 14040:2006 Environmental Management — Life Cycle Assessment — Principles and Framework

ISO 14044:2006 Environmental Management — Life Cycle Assessment — Requirements and Guidelines

ISO 14050:2009 Environmental Management — Vocabulary

ISO 15686-1:2011 Buildings and Constructed Assets — Service life planning — Part 1: General Principles and Framework

ISO 21930:2017 Sustainability in Building Construction — Environmental Declaration of Building Products

Other References:

BS EN 15804 *Sustainability of construction works—Environmental product declarations—Core rules for the product category of construction products*[8]

[5] Available from ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, http://www.astm.org.

[6] Available from CSA Group, 178 Rexdale Boulevard, Toronto, ON Canada M9W 1R3, http://www.csagroup.org

[7] Available from International Organization for Standardization (ISO), 1, ch. de la Voie-Creuse, CP 56, CH-1211 Geneva 20, Switzerland, http://www.iso.org.

[8] European Committee for Standardization (CEN), Avenue Marnix 17, B-1000 Brussels, Belgium, *www.cen.eu*

Appendix A

Table A1: Plastic Plumbing Piping System Specifications for an Average 1000 square foot Residential Dwelling*

	ft of pipe required for 1000 sq ft of a **1367 sq ft one-story house**	*ft of pipe required for 1000 sq ft of a* **2811 sq ft two-story house**	*ft of pipe required for 1000 sq ft of a* **4402 sq ft two-story house**	***ft of pipe required for an average 1000 sq ft residential dwelling*** **To be scaled according to the EPDs needs**
DWV (Drain, Waste, Vent)				
1½ inch	5.5	0	0	1.8
2 inch	87.8	59.4	46.9	64.7
3 inch	38.0	51.4	33.6	41.0
4 inch	0	0	3.4	1.1
Total feet of pipe	131.3	110.8	83.9	108.7
Total number of fittings	35.8	28.1	24.5	29.5
Water Supply				
1 inch	21.9	10.7	6.8	13.1
HCWD (Hot and Cold Water Distribution)				
½ inch	138.3	84.7	78.8	100.6
¾ inch	55.6	57.3	26.8	46.6
1 inch	0	11.4	20.0	10.5
Total feet of pipe	193.9	153.3	125.6	157.6
Total number of fittings				
For rigid pipe (CPVC)	56.3	33.1	34.5	41.3
For flexible pipe (PEX)	33.7	18.9	19.5	24.0

Source: *Peer Reviewed Life Cycle Inventory for the Production and Use of Installed Residential Piping Systems for Three House Layouts*, for PPFA, Franklin Associates, 2011

* For other applications similar tables should be developed and documented in the EPD.

Table A2: Plastic Plumbing Piping System Specifications for an Average 1000 square foot Residential Dwelling

		1367 sq ft one-story house				2811 sq ft two-story house				4402 sq ft two-story house				Average for 1000 sq ft of a typical residential dwelling			
Pipe type	**Fitting type**	**Pipe**		**Fittings**	**Solder/ adhesive**	**Pipe**		**Fittings**	**Solder/ adhesive**	**Pipe**		**Fittings**	**Solder/ adhesive**	**Pipe**		**Fittings**	**Solder/ adhesive**
		ft	***lb***	***lb***	***lb***	***ft***	***lb***	***lb***	***lb***	***ft***	***lb***	***lb***	***lb***	***ft***	***lb***	***lb***	***lb***
DWV (Drain, Waste, Vent)																	
PVC Solid	PVC	131.3	107.5	28.2	2.8	110.8	107.8	22.3	2.3	83.9	81.8	20.4	2.1	108.7	99.0	23.7	2.4
PVC Cellular Core	PVC	131.3	67.5	28.2	2.8	110.8	67.9	22.3	2.3	83.9	51.3	20.4	2.1	108.7	62.3	23.7	2.4
ABS Solid	ABS	131.3	80.5	28.2	2.8	110.8	79.3	17.4	2.3	83.9	60.9	17.2	2.1	108.7	73.6	20.9	2.4
ABS Cellular Core	ABS	131.3	54.4	28.2	2.8	110.8	53.4	17.4	2.3	83.9	40.9	17.2	2.1	108.7	49.5	20.9	2.4
Water Supply																	
PE (HDPE, LLDPE)	-	21.9	3.5	0	0	10.7	1.7	0	0	6.8	0	0	0	13.1	1.7	0	0
PVC	-	21.9	7.0	0	0	10.7	3.4	0	0	6.8	0	0	0	13.1	3.5	0	0
HCWD (Hot and Cold Water Distribution)																	
CPVC	CPVC	193.9	20.0	2.1	0.9	153.3	18.0	1.5	0.5	125.6	15.1	1.4	0.5	157.6	17.7	1.7	0.6
PEX	Brass	193.9	15.0	5.9	0	153.3	13.6	3.3	0	125.6	11.3	3.7	0	157.6	13.3	4.3	0
PEX	Polysulfone/ Brass	193.9	15.0	1.6	0	153.3	13.6	1.1	0	125.6	11.3	1.2	0	157.6	13.3	1.3	0

Source: *Peer Reviewed Life Cycle Inventory for the Production and Use of Installed Residential Piping Systems for Three House Layouts*, for PPFA, Franklin Associates, 2011

Note: *The length of pipe shown in the table is the length in the installed layout. The weight of the pipe shown in the table includes the weight of the installed pipe and installation scrap.*

Table A3: Piping System Fittings for an Average 1000 Linear Foot of Building Piping

Rigid Water Distribution Piping Fittings, 1000 feet	**258**
Flexible Water Distribution Piping Fittings, 1000 feet	**148**
Rigid DWV Piping Fittings, 1000 feet	**234**

Source: *Derived from Peer Reviewed Life Cycle Inventory for the Production and Use of Installed Residential Piping Systems for Three House Layouts*, for PPFA, Franklin Associates, 2011