ERDC/CERL TN-23-1
November 2023

The Importance of Environmental Product Declarations in the Decarbonization Effort

By Megan R. Fuhler, Brent D. Panozzo, Birgitte R. Dodd, Dylan A. Pasley, Allison R. Young

PURPOSE: An Environmental Product Declaration (EPD) is a disclosure document that communicates how a product or material affects the environment throughout its life cycle. EPDs are used across many industries and government organizations as an accurate source of information when making procurement decisions to minimize environmental impacts. Developed by businesses and certified by third-party organizations, EPDs are created to communicate the environmental impacts of specified life-cycle stages of a product. As such, EPDs can be an important tool for organizations working toward carbon reduction goals, such as the Army's decarbonization goals of Executive Order (EO) 14,057 and the *Army Climate Strategy*.

This document summarizes the current state of EPDs, including how they are created, how they can be used to help analyze the environmental impacts of construction materials, and how they are being used by government entities. Also discussed are other decarbonization tools and methods to integrate EPDs, providing a more wholistic approach to the construction industry's activities and impacts. The document concludes with a discussion of the challenges and the future of EPDs.

BACKGROUND: The DoD and Army have undertaken significant steps to tackle challenges in climate change adaptation and mitigation in support of Executive Orders 14,008 on climate change and 14,057 on clean energy and sustainability. These executive orders direct the US government toward short and long-term goals to reduce greenhouse gas (GHG) emissions. Strategies to achieve these climate goals are outlined in several climate and sustainability documents, including the Federal Buy Clean Initiative and the *Army Climate Strategy* and its implementation plan. Furthermore, EO 14,057 contains a goal of achieving net-zero emissions during procurement with the addition of a Buy Clean policy to promote sustainable construction materials.

EPDs are the standard method for identifying and comparing the impacts of materials in the construction industry. Although there is a growing effort to understand and use EPDs as a tool to achieve sustainability goals, they have been used across industry for 25 years. According to EPD Australia, the first EPD was published by the European energy infrastructure company Vattenfall. Published in 1998, the EPD offered information on the environmental impacts from producing hydroelectricity from a river in Sweden. (EPD Australia 2023).

ENVIRONMENTAL PRODUCT DECLARATION (EPD) OVERVIEW: The International Organization for Standardization (ISO) 14025 defines an EPD as a Type III environmental declaration that "quantifies environmental information on the life cycle of a product to enable comparisons between products fulfilling the same function" (ISO 2006). In other words, an EPD

is a disclosure document meant to communicate the ways in which a product, throughout its life cycle, affects the environment. There are several data points required to establish an EPD, including material and energy data inputs (Building Transparency, n.d.). The foundation of an EPD is a life-cycle assessment (LCA), which evaluates a product's environmental performance throughout its life cycle. The material extraction, the manufacturing process of a product, its usage stage, and end of life are typically considered during the evaluation (EPD International, n.d., "What is an ..... E ..... P ..... D ....."). According to the AIA (American Institute of Architects) (2018), "the LCA informing an EPD details product information related to the resource use, greenhouse gas and other emissions, waste generation, and other environmental impacts throughout the product's life cycle. EPDs may also include other environmental data, including information about the company's overall work in the environment and social responsibility, or on product development."

The path to creating an EPD, as well as the information it will contain, is variable. Depending on the guidelines established for the material and the specific LCA method utilized, an EPD will communicate a variety of impact categories (Wu 2020). Some of the more common impact categories are described in Table 1 below (Feng 2023).

Table 1. Common impact categories with units of measure and descriptions.

Impact Factor	Units of Measure	Description
Global Warming Potential (GWP)	kg CO_2* eq	Quantifies the amount of expended energy
Primary Energy	MJ, net calorific value	All energy, direct or indirect, used to transport or transform raw materials into products
Acidification Potential	kg SO_2 eq	Potential to cause ocean acidification due to the uptake of CO_2 from the atmosphere
Eutrophication Potential	kg N eq	Potential to cause excess nutrient buildup in water bodies
Ozone Depletion Potential	kg CFC-11 eq	Potential to cause depletion of the ozone layer
Ozone Creation Potential	kg NMVOC eq	Potential to create smog

* For a full list of the spelled-out forms of the chemical elements used in this document, please refer to *US Government Publishing Office Style Manual*, 31st ed. (Washington, DC: US Government Publishing Office, 2016), 265, https://www.govinfo.gov/content/pkg/GPO-STYLEMANUAL-2016/pdf/GPO-STYLEMANUAL-2016.pdf.

It is important to note that although an EPD is generated by following internationally coordinated ISO frameworks and product category rules, there is currently no requirement within the US to register an EPD with the international EPD System (GSA 2022). This lack of centralization further enables variations to arise across EPD documents. Therefore, to get a clear understanding of EPDs, it is best to understand how they are created.

How EPDs are established. Figure 1 shows the framework for creating an EPD beginning with defining the project category rules (PCRs) and ending with the registration of the EPD.

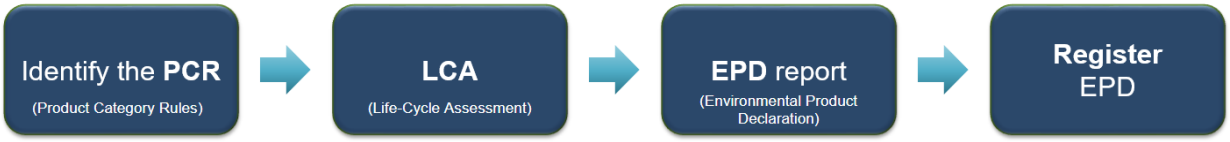


Figure 1. Framework for creating an Environmental Product Declaration (EPD) (modified from Dvecheve 2019).

When creating an EPD, it is important to first define the product and what category that product falls under. A product category is a group of products that fulfill similar functions (i.e., insulation, concrete blocks, or floor finishes). Once the product and product categories are defined, the correct PCR can be found or created in compliance with ISO standards 14025 and 21930. If a PCR does not exist yet, it must be created by the program operator. The PCR defines the rules, requirements, and guidelines used in developing EPDs. The PCR also defines the LCA requirements, including the following:

- Functional units
- Life-cycle stages
- Impact categories to report
- Verification procedures

PCRs are established through an open development process that allows stakeholder review and feedback on the PCR (CLF 2020b). The development and publication of a PCR is led by a program operator, who is also responsible for stakeholder correspondence and related EPDs. A program operator may be a company, industry sector association, trade association, public agency, or other independent body (Boguski 2020).

Each material PCR dictates methodological decisions that are relevant and fine-tuned to the supply chain of that product category (e.g., precast concrete, single-ply roofing membrane, slag cement, insulated metal panels, etc.). High-quality, detailed PCRs are more likely to result in consistent and better quality EPDs. Less-detailed PCRs could lead to different interpretations of the guidance and possibly introduce some variance in the resulting EPDs.

To create an EPD, a manufacturer must search existing PCRs to find an applicable PCR for their product. There are several repositories for PCRs, like those listed below:

- https://www.nsf.org/standards-development/product-category-rules
- https://www.ul.com/services/product-category-rules-pcrs

As part of the LCA, a life-cycle inventory analysis (LCI) and a life-cycle impact assessment (LCIA) are conducted. The LCI is a phase in which the data for the study is collected and input and outputs are understood. The LCIA is meant to analyze the product for environmental impact by tracking the flows into and out of the environment (ASMI, n.d.). LCA professionals will refer

to the relevant PCR guidance when conducting their analysis. Once the LCA is established, it must be verified before the EPD is created.

Using the LCA report, as defined by the PCR, the resulting EPD document serves as a report on the findings of this process and must be registered. EPDs are currently static documents, but with the possible integration with software tools, design tools, and a database, there is a potential for them to become dynamic. Also included in the EPD are any additional environmental information, materials, and substances to be declared and the period in which the EPD is valid. EPDs are typically valid for five years after the date of publication. At the end of five years, another survey is conducted to collect new data on any advancements or other changes within the industry.

Rules and standards for the creation of EPDs. EPDs are applicable to all product divisions and types as defined by the Construction Specification Institute (CSI). The scope of an EPD is limited to the defined product category and to information related to environmental impacts (AIA 2018).

As previously mentioned, the ISO has produced several standards relating to product category rules, LCAs, and EPD creation. Table 2 provides a list of the relevant ISO standards and a link to where they can be found.

Table 2. International Organization for Standards: EPD and life-cycle assessment (LCA) standards.

ISO Standard	Description	Link
ISO 14020	*Environmental Labels and Declarations—General Principles*	https://www.iso.org/standard/79479.html
ISO 14025	*Environmental Labels and Declarations—Type III Environmental Declarations—Principles and Procedures*	https://www.iso.org/standard/38131.html
ISO 14027	*Environmental Labels and Declarations—Development of Product Category Rules*	https://www.iso.org/standard/66123.html
ISO 14040	*Environmental Management—LCA—Principles and Framework*	https://www.iso.org/standard/37456.html
ISO 14044	*Environmental Management—LCA—Requirements and Guidelines*	https://www.iso.org/standard/76122.html
ISO 14071	*Environmental Management—LCA—Critical Review Processes and Reviewer Competencies: Additional Requirements and Guidelines to ISO 14044*	https://www.iso.org/standard/61103.html
ISO 21930	*Sustainability in Buildings and Civil Engineering Works—Core Rules for Environmental Product Declarations of Construction Products and Services*	https://www.iso.org/standard/61694.html

Furthermore, ISO 14025 indicates that these declarations are

- provided by at least one organization,
- based on LCAs that have been independently verified, LCI analysis data, or other modules that have been created in accordance with ISO series 14040,
- developed using predetermined parameters, and
- administered by a program operator.

Types of environmental labels and declarations. ISO standards identify three categories of environmental claims for products. The focus of this report is type III claims, which allow the production of a verified EPD document.

- Type I Claim (Eco Labeling): Third-party verified program that awards a license that allows a product to use an environmental label of an established ecolabeling program. Authorization to use the label requires products to be assessed to ensure the required criteria are met (governed by ISO 14024). One example is the Energy Star Program.
- Type II Claim: An informative self-declaration by manufacturers or retailers (governed by ISO 14021) used to highlight an individual environmental aspect of a product or service. Not required to be third-party verified. These claims may take the form of statements, graphics, product labeling, and marketing.
- Type III Claim: Contains quantified environmental information of a product based on verified LCAs (governed by ISO 14025). Only this type of claim can result in a verified EPD document. Type III EPDs are administered by a program operator, and assessments follow preset guidelines (product category rules). Type III claims can be further classified depending on the specificity of the data used in the LCA.

Per the Carbon Leadership Forum, "type III EPD declarations contain the greatest amount of quantified information" on the environmental impacts of a product and are based on verified LCAs, which provides opportunity to compare products with the same function as required in ISO 14025" (Lewis 2021). Type III EPDs are further categorized by the level of specificity as show in Figure 2 and as defined herein.

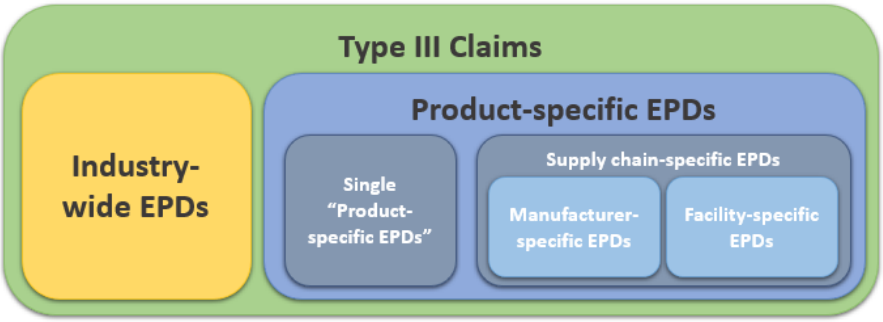


Figure 2. Type III EPDs.

Industry-wide EPDs. An EPD that represents the manufacturing impacts of a product across many different manufactures based on industry-average data are considered industry-wide EPDs. These types of EPDs "provide the least-specific data on a product's embodied carbon footprint . . . but are helpful in understanding the typical impact of a product" (Lewis 2021). Industry-wide EPDs can be used as a benchmark for specific EPDs but cannot be compared to each other. Figure 3 and Figure 4 provides an excerpt from the industry-wide EPD for Portland cement. See Table 3 for information on the number and types of industry-wide EPDs related to construction materials. As seen in this table, there are a limited number of industry-wide EPDs available.

PCA Since 1916
America's Cement Manufacturers™

ENVIRONMENTAL PRODUCT DECLARATION
PORTLAND CEMENT

ASTM Certification page

This document is a Type III industry-average Environmental Product Declaration (EPD) describing portland cements produced in the United States (US) by Portland Cement Association (PCA) members. The results of the underlying LCA are computed with the *North American (N.A.) version of the Global Cement and Concrete Association (GCCA) Industry EPD tool for cement and concrete* [4]. This tool and the underlying LCA model and database have been previously verified to conform to the prevailing sub-product category rule (PCR) [11], ISO 21930:2017 (the core PCR) [10] as well as ISO 14025:2006 [7] and ISO 14040/44:2006 Amd: 2020 LCA standards [8], [9].

This EPD is certified by ASTM to conform to the Sub-Product Category Rule (PCR) referenced below, as well as to the requirements of ISO 14025 and ISO 21930.

DECLARATION HOLDER	Portland Cement Association 5420 Old Orchard Road Skokie, IL, USA 60077-1083 www.cement.org
DECLARATION NUMBER	EPD 195
PRODUCT GROUP AND NAME	Cement, UN CPC 3744
DECLARED PRODUCT	Portland cement(s) as a category product
REFERENCE PCR	NSF Product Category Rule for *Preparing an Environmental Product Declaration for Portland, Blended Hydraulic, Masonry, Mortar, and Plastic (Stucco) Cements.* V3.1, September 2020.
PROGRAM OPERATOR	ASTM International 100 Barr Harbor Drive West Conshohocken, PA, USA 19428-2959 www.astm.org
DATE OF ISSUE	03-12-2021
PERIOD OF VALIDITY	03-12-2021- 03-12-2026
NOTES	The EPD results are computed using the *N.A. version of GCCA Industry EPD tool for Cement and Concrete* (https://concrete-epd-tool.org).

Figure 3. Certification page from the industry-wide EPD for Portland cement as produced by the Portland Cement Association. (PCA 2021.)

PCA Since 1916
America's Cement Manufacturers™

ENVIRONMENTAL PRODUCT DECLARATION
PORTLAND CEMENT

Life cycle assessment results

The cradle-to-gate (A1 to A3) EPD results for producing one metric ton of portland cement are presented in Table 4.

Table 4. Production stage EPD results for portland cements.

Impact category and inventory indicators	Unit	Portland Cements 1 metric ton
Global warming potential, GWP 100, IPCC 2013	kg CO_2 eq	**922**
Ozone depletion potential, ODP	kg CFC-11 eq	**2.10E-05**
Acidification potential, AP	kg SO_2 eq	**1.75**
Eutrophication potential, EP	kg N eq	**1.02**
Smog formation potential, SFP	kg O_3 eq	**32.9**
Abiotic depletion potential for non-fossil mineral resources, ADP elements*	kg Sb eq	**1.97E-04**
Abiotic depletion potential for fossil resources, ADP fossil*	MJ Surplus	**363**
Renewable primary resources used as an energy carrier (fuel), RPR_E*	MJ LHV	**138.4**
Renewable primary resources with energy content used as material, RPR_M*	MJ LHV	**3.55**
Non-renewable primary resources used as an energy carrier (fuel), $NRPR_E$*	MJ LHV	**4080**
Non-renewable primary resources with energy content used as material, $NRPR_M$*	MJ LHV	**4.75**
Secondary materials, SM*	kg	**95.8**
Renewable secondary fuels, RSF*	MJ LHV	**54.3**
Non-renewable secondary fuels, NRSF*	MJ LHV	**523**
Net use of freshwater, NFW*	m^3	**1.04**
Hazardous waste disposed, HWD*	kg	**0.013**
Non-hazardous waste disposed, NHWD*	kg	**309**
High-level radioactive waste, conditioned, to final repository, HLRW*	kg	**x[1)]**
Intermediate- and low-level radioactive waste, conditioned, to final repository, ILLRW*	kg	**x[1)]**
Components for re-use, CRU*	kg	**0**
Materials for recycling, MFR*	kg	**0.52**
Materials for energy recovery, MER*	kg	**0**
Recovered energy exported from the product system, EE*	MJ LHV	**1.94**
Additional Inventory Parameters for Transparency		
Global warming potential - biogenic, GWP_{bio}*	kg CO_2 eq	**0.72**
Emissions from calcination*	kg CO_2 eq	**480**
Emissions from combustion of waste from renewable sources*	kg CO_2 eq	**0.203**
Emissions from combustion of waste from non-renewable sources*	kg CO_2 eq	**48.8**

[1)] x – Not all LCA datasets for upstream materials include these impact categories and thus results may be incomplete.
*) Use caution when interpreting results for these categories

Figure 4. Results page from the industry-wide EPD for Portland cement as produced by the Portland Cement Association. (PCA 2021.)

Table 3. Number of industry-wide EPDs by type as of October 2021 (Reproduced and modified with permission from Graves 2022).

Material Category	North America	Outside of North America	Total
Concrete	2 (+2 expired)	0	2 (+2 expired)
Unite Masonry	0 (+1 expired)	0	0 (+1 expired)
Steel	9	1	10
Aluminum	8	2	10
Wood	16	10	26

Product-specific EPDs. Any type III EPD not considered an industry-wide EPD is generally definied as a product-specific EPD. Type III, product-specific, third-party-certified EPDs are the most useful type III EPD because they undergo the most vigorous verification process and provide the most specifc environmental impact data for the product.

Product-specific EPDs are more common than industry-wide EPDs. As of October 2021, there were 59,214 product-specific EPDs in the US, with largely varying numbers by state as seen in Figure 5. The majority of the EPD development (80%) comes from two states: California (57%) and New Jersey (23%).

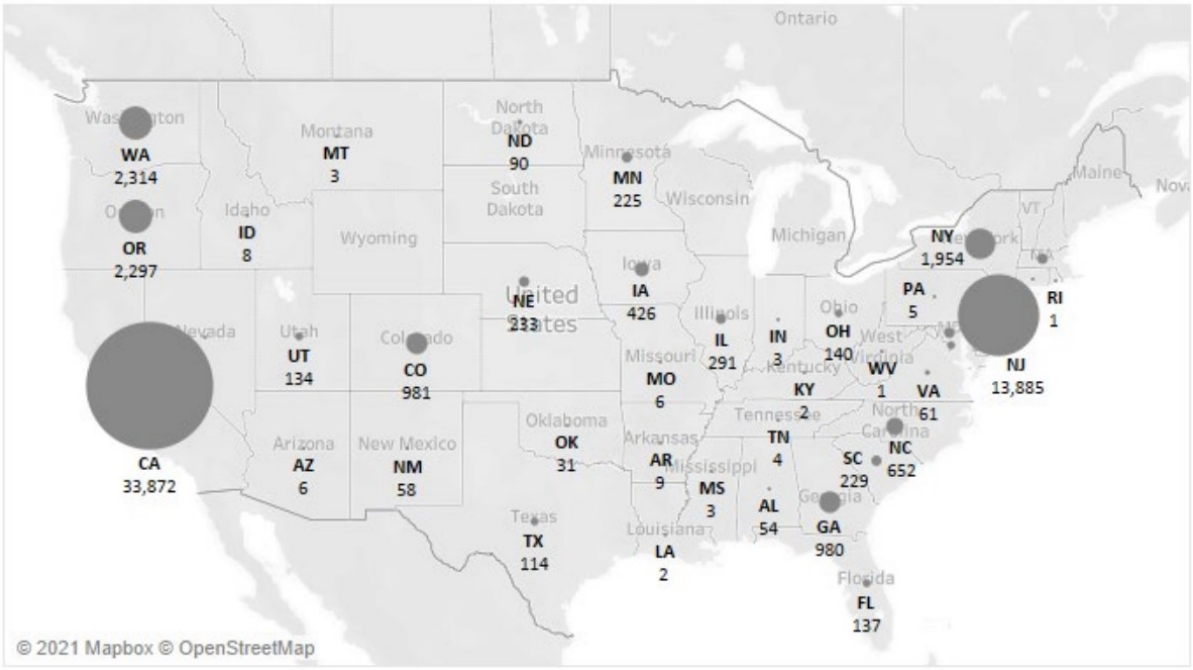


Figure 5. Total number of product-specific EPDs by state. Based on data exported from the Embodied Carbon in Construction Calculator (EC3) on 24 October 2021. Not shown: Hawaii, which had zero EPDs, and Alaska, which had one EPD. (Image reproduced with permission from Graves 2022. OpenStreetMap. Map data from OpenStreetMap contributors, 2022. Open Database License.)

Most product-specific EPDs are for concrete, predominately ready-mix concrete. An example of a product-specific EPD can be found in Figure 6.

CALPORTLAND

EPD
ENVIRONMENTAL PRODUCT DECLARATION

READY MIX CONCRETE PRODUCED BY: CalPortland

FACILITY:	Tumwater
STRENGTH:	100 psi @ 28 days
MIX NAME:	0570

IMPACT INDICATOR		PER YD3	PER M3
Climate Change	kg CO_2e	121.75	159.24
Ozone Depletion	kg CFC11e	2.84E-06	3.71E-06
Acidification	kg SO2e	0.57	0.75
Eutrophication	kg NE	0.14	0.19
Smog Formation	kg O3e	13.48	17.63
Non-renewable energy	MJ, NCV	961.75	1257.92

GENERAL INFORMATION	
Declared Product and EPD Number	Ready-Mixed Concrete Produced by CalPortland ; NRMCA EPD 20026
Date of Issue	August 29, 2023
Period of Validity	5 years; August 27, 2026
EPD Holder	CalPortland 2025 E Financial Way Glendora, CA 91741
Program Operator	National Ready Mix Concrete Association 66 Canal Center Plaza, Suite 250, Alexandria, VA 22314
LCA and EPD Developer	WAP Sustainability Consulting 1701 Market Street Chattanooga, TN 37408 www.wapsustainability.com
Core PCR	ISO 21930:2017 Sustainability in Building Construction - Environmental Declaration of Building Products
Sub-category PCR	NSF International Product Category Rule (PCR) for Concrete Version 2.2 (December 2022), Verified by Thomas P. Gloria, Ph.D., Industrial Ecology Consultants
Independent LCA Reviewer and EPD Verifier	Independent verification of the declaration and data, according to ISO 21930:2017 and ISO 14025:2006
	Cara Vought, LCACP, LEED AP +ID+C, Sustainable Solutions Corporation ☐ Internal ☒ External
For additional explanatory material	Manufacturing Representative: Gary Kirk (gkirk@calportland.com) Software: Theta by WAP Sustainability Consulting V.1.0

The declared product meets the following product specifications:

- ACI 211: Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete.
- ACI 318: Building Code Requirements for Structural Concrete.
- ASTM C94 Standard Specification for Ready-Mixed Concrete.
- CSA A23.1/A23.2: Concrete Materials and Methods of Concrete Construction
- CSI Masterformat Division 03-30-00: Cast-in-Place Concrete.
- UNSPSC Code 30111500: Ready Mix

Disclaimers: EPDS are comparable only if they comply with this document, use the same sub-category PCR where applicable, include all relevant information modules and are based on equivalent scenarios with respect to the context of construction works.

This EPD was calculated using industry average cement data. Cement LCA impacts can vary depending upon manufacturing process, efficiency and fuel source by as much as 50% for some environmental impact categories. Cement accounts for as much as 90% of the impacts of the concrete mixes included in this EPD and thus manufacturer specific cement impacts could result in variation of as much as 45%.

Figure 6. Summary page from CalPortland's product-specific EPD for 100-psi-at-28-days ready-mix concrete from the Turnwater facility.[1]

1. For a full list of the spelled-out forms of the units of measure used in this document and their conversions, please refer to US Government Publishing Office Style Manual, 31st ed. (Washington, DC: US Government Publishing Office, 2016), 248–52 and 345–47, https://www.govinfo.gov/content/pkg/GPO-STYLEMANUAL-2016/pdf/GPO-STYLEMANUAL-2016.pdf.

Other product-specific EPDs include masonry, aluminum, steel, and wood. Table 4 shows the vast disparity in the number of EPDs and that some industries have very few product-specific EPDs (as of October 2021).

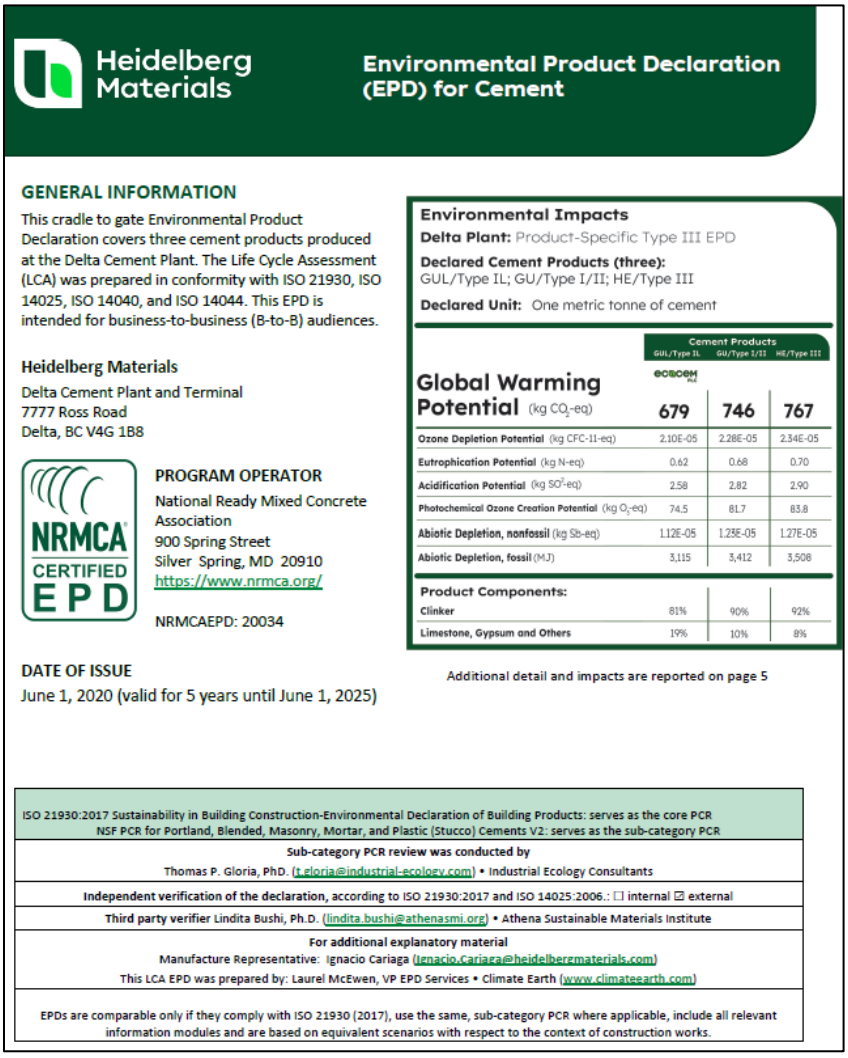
Table 4. Snapshot of product-specific EPDs. (Reproduced with permission from Graves 2022.)

Product-Specific EPDs by State									
Material Category	**Material Subcategory**	**Grand Total**	**State/Province**						
			CA	**NJ**	**WA**	**OR**	**NY**	**CO**	**MN**
Grand Total		55,528	33,872	13,885	2,314	2,297	1,954	981	225
Concrete	Total	55,381	33,780	13,882	2,294	2,282	1,951	968	224
	Ready-mix	51,820	30,832	13,773	2,115	2,062	1,931	904	203
	Flowable fill	1,539	1,329	24	57	66	7	35	21
	Shotcrete	1,343	1,154	2	83	83	—	21	—
	Cement grout	475	380	20	33	39	1	2	—
	Concrete paving	195	76	63	6	32	12	6	—
	Precast concrete	9	9	—	—	—	—	—	—
Masonry	Total	98	77	—	9	—	—	12	—
	CMU	98	77	—	9	—	—	12	—
Aluminum	Total	3	3	—	—	—	—	—	—
	Alum. Extrusions	2	2	—	—	—	—	—	—
	Alum. Suspension assembly	1	1	—	—	—	—	—	—
Steel	Total	32	11	3	10	3	3	1	1
	Rebar-steel	25	7	3	8	3	3	1	—
	Cold-formed steel	5	3	—	2	—	—	—	—
	Hot-rolled	1	—	—	—	—	—	—	1
	Misc. metal fabrication	1	1	—	—	—	—	—	—
Wood	Total	14	1	—	1	12	—	—	—
	Sheathing panels	4	1	—	—	3	—	—	—
	Wood joists	4	—	—	—	4	—	—	—
	Mass timber	2	—	—	1	1	—	—	—
	Composite lumber	1	—	—	—	1	—	—	—
	Nonstructural wood	1	—	—	—	1	—	—	—
	Prefabricated wood	1	—	—	—	1	—	—	—
	Wood framing	1	—	—	—	1	—	—	—

Product-specific EPDs may be further classified depending on the specificity of the data sources used. Additional factors considered when classifying EPDs include if the data are specific to a single manufacture or a single facility and to what degree is the supply-chain data incorporated into the product data.

Supply-chain-specific EPDs. As first defined in Washington HB 1103 (Buy Clean Buy Fair Washington), "A supply chain-specific EPD is a product specific EPD that uses supply chain-specific data in the LCA to model the impacts of key processes upstream in a product's supply chain." Supply-chain-specific EPDs use primary upstream data to more accurately represent the impacts of a product. Although this type of EPD will provide a more accurate assessment of environmental impacts, they are not widely available and manufacturer guidance still needs to be established.

Facility-specific EPDs. Facility-specific EPDs represent a product produced at a single facility by a single manufacturer. They were introduced by the Buy Clean California Act (BCCA) in 2017. Because facility-specific EPDs are acceptable through BCCA, they may become more prominent in the construction industry. Figure 7 provides a sample page from a facility-specific EPD published online. This page shows the general information included in the EPD and specifically calls out the three products being declared from a specific cement plant owned and operated by Heidelberg Materials.



Heidelberg Materials

Environmental Product Declaration (EPD) for Cement

GENERAL INFORMATION

This cradle to gate Environmental Product Declaration covers three cement products produced at the Delta Cement Plant. The Life Cycle Assessment (LCA) was prepared in conformity with ISO 21930, ISO 14025, ISO 14040, and ISO 14044. This EPD is intended for business-to-business (B-to-B) audiences.

Heidelberg Materials
Delta Cement Plant and Terminal
7777 Ross Road
Delta, BC V4G 1B8

NRMCA CERTIFIED EPD

PROGRAM OPERATOR
National Ready Mixed Concrete Association
900 Spring Street
Silver Spring, MD 20910
https://www.nrmca.org/

NRMCAEPD: 20034

DATE OF ISSUE
June 1, 2020 (valid for 5 years until June 1, 2025)

Environmental Impacts
Delta Plant: Product-Specific Type III EPD
Declared Cement Products (three): GUL/Type IL; GU/Type I/II; HE/Type III
Declared Unit: One metric tonne of cement

	Cement Products GUL/Type IL	GU/Type I/II	HE/Type III
Global Warming Potential ($kg\ CO_2$-eq)	679	746	767
Ozone Depletion Potential (kg CFC-11-eq)	2.10E-05	2.28E-05	2.34E-05
Eutrophication Potential (kg N-eq)	0.62	0.68	0.70
Acidification Potential ($kg\ SO^2$-eq)	2.58	2.82	2.90
Photochemical Ozone Creation Potential ($kg\ O_3$-eq)	74.5	81.7	83.8
Abiotic Depletion, nonfossil (kg Sb-eq)	1.12E-05	1.23E-05	1.27E-05
Abiotic Depletion, fossil (MJ)	3,115	3,412	3,508
Product Components:			
Clinker	81%	90%	92%
Limestone, Gypsum and Others	19%	10%	8%

Additional detail and impacts are reported on page 5

ISO 21930:2017 Sustainability in Building Construction-Environmental Declaration of Building Products: serves as the core PCR
NSF PCR for Portland, Blended, Masonry, Mortar, and Plastic (Stucco) Cements V2: serves as the sub-category PCR

Sub-category PCR review was conducted by
Thomas P. Gloria, PhD. (t.gloria@industrial-ecology.com) • Industrial Ecology Consultants

Independent verification of the declaration, according to ISO 21930:2017 and ISO 14025:2006.: ☐ internal ☑ external

Third party verifier Lindita Bushi, Ph.D. (lindita.bushi@athenasmi.org) • Athena Sustainable Materials Institute

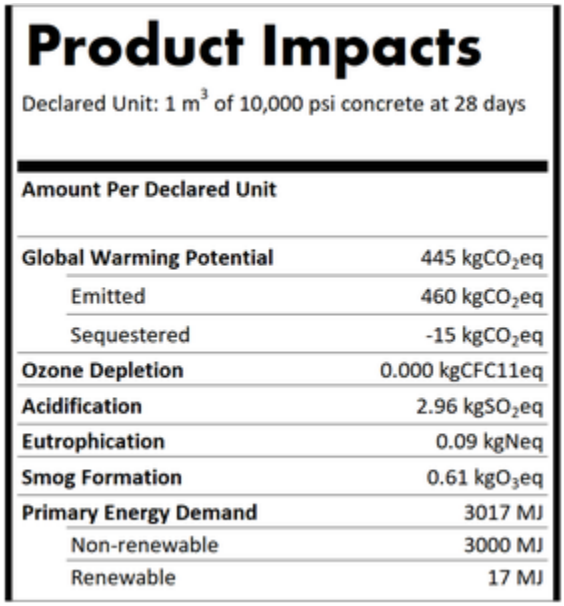
For additional explanatory material
Manufacture Representative: Ignacio Cariaga (Ignacio.Cariaga@heidelbergmaterials.com)
This LCA EPD was prepared by: Laurel McEwen, VP EPD Services • Climate Earth (www.climateearth.com)

EPDs are comparable only if they comply with ISO 21930 (2017), use the same, sub-category PCR where applicable, include all relevant information modules and are based on equivalent scenarios with respect to the context of construction works.

Figure 7. First page of a publicly published, facility-specific EPD created for Heidelberg Materials.

Manufacturer-specific EPDs. Manufacturer-specific EPDs represent all products produced by a single manufacturer. This type of EPD may contain several product-specific EPDs within the same document as long as those products are made by the same manufacturer.

Reading and comparing EPDs. EPDs are commonly referred to as a "nutrition label" for the environmental impacts of a product or material. Figure 8 is an example of an EPD in the format of a nutrition label. Like a nutrition label, EPDs provide quantified data about the product. Where nutrition labels provide data on the nutritional impact of food products, EPDs provide data on the environmental impact of a product (Building Transparency, n.d.). Unlike nutrition labels, there is not an allotted "daily value" for the impact categories. EPDs provide quantified environmental impact data, but the report does not provide a judgment on those values.



Product Impacts

Declared Unit: 1 m^3 of 10,000 psi concrete at 28 days

Amount Per Declared Unit	
Global Warming Potential	445 $kgCO_2eq$
Emitted	460 $kgCO_2eq$
Sequestered	-15 $kgCO_2eq$
Ozone Depletion	0.000 kgCFC11eq
Acidification	2.96 $kgSO_2eq$
Eutrophication	0.09 kgNeq
Smog Formation	0.61 kgO_3eq
Primary Energy Demand	3017 MJ
Non-renewable	3000 MJ
Renewable	17 MJ

Figure 8. Sample EPD formatted as a "nutrition label." (Image reproduced with permission from Building Transparency, n.d.)

The American Institute of Architects recommends that practitioners interpret EPDs with "the guidance of an expert. Designers should either consult with a materials science professional to evaluate the information . . . or reference guidance to meet standards included in applicable certification programs" (i.e., Leadership in Energy and Environmental Design [LEED] v4, Building Research Establishment Environmental Assessment Method [BREEAM], or Green Globes) (AIA 2018). Designers can also "qualify products based on whether they do or do not offer an EPD" (AIA 2018). Direct comparison of EPDs is only appropriate between products following the same PCR. Products following the same PCR can be compared because they are functionally equivalent, use the same system boundaries, and use the same upstream data. Comparability between EPDs may still vary depending on the quality of the PCR and compliance with the PCR guidelines (AIA 2018).

Determining which registries to utilize can be confusing for design and construction engineers. There are several registries globally that house construction-material-related EPDs. A list of common EPD databases is provided in the APPENDIX: EPD Databases.

Examples of EPDs. Although EPDs must follow established ISO standards when being created, there is no standard format for the output document. In addition to the ISO standards, a product's PCR will also provide some guidelines for creating the EPD document. Due to this lack of regularity, EPDs can look different across products and manufactures.

Below are sample EPDs for concrete (Figure 9) and asphalt mixes (Figure 10).

ENVIRONMENTAL IMPACTS Declared Products: Description:Exterior 4000 PSI Compressive strength: 4000 PSI at 28 days Declared Unit: 1 m^3 of concrete	
Global Warming Potential (kg CO -eq)	318
Ozone Depletion Potential (kg CFC-11-eq)	7.15E-6
Acidification Potential (kg SO -eq)	0.95
Eutrophication Potential (kg N-eq)	0.24
Photochemical Ozone Creation Potential (kg O -eq)	20.7
Abiotic Depletion, non-fossil (kg Sb-eq)	5.82E-5
Abiotic Depletion, fossil (MJ)	658
Total Waste Disposed (kg)	94.2
Consumption of Freshwater (m^3)	2.40
Product Components: natural aggregate (ASTM C33), Portland cement (ASTM C150), fly ash (ASTM C618), batch water (ASTM C1602), admixture (ASTM C494), admixture (ASTM C260)	

Figure 9. Sample information from a concrete EPD. (FHWA 2023. Public domain.)

An Environmental Product Declaration for Asphalt Mixtures		
PRODUCT DESCRIPTION Gradation Type: dense Mix Design Method: superpave Nominal Maximum Aggregate Size: 12.5 mm Performance Grade of Asphalt Binder: PG 58-28 This mix producer categorizes this product as a Hot Mix Asphalt (HMA) asphalt mixture. This asphalt mixture was produced within a temperature range of 150 to 161°C		
IMPACT CATEGORY	POTENTIAL IMPACT PER METRIC TONNE ASPHALT MIXTURE (PER TON ASPHALT MIXTURE)	
Global warming potential (GWP-100)	*71.05 (64.46) kg CO2 Equiv.*	
Ozone depletion potential (ODP)	*9.92e-08 (9.00e-08) kg CFC-11 Equiv.*	
Eutrophication potential (EP)	*1.24e-02 (1.13e-02) kg N Equiv.*	
Acidification potential (AP)	*1.72e-01 (1.56e-01) kg SO2 Equiv.*	
Photochemical ozone creation potential (POCP)	*4.51 (4.09) kg O3 Equiv.*	
DECLARED UNIT: The declared unit is 1 metric tonne (1 short ton) of an asphalt mixture		
PRODUCT INGREDIENTS		
Component	*Material*	*Weight %*
Aggregate	*Natural Stone*	*15*
Aggregate	*Natural Stone*	*21*
Aggregate	*Natural Stone*	*13*
Aggregate	*Natural Stone*	*14*
Aggregate	*Natural Stone*	*8*
RAP	*Reclaimed Asphalt Pavement*	*24*
Binder	*Unmodified*	*4*

Figure 10. Sample information from an asphalt EPD. (FHWA 2023. Public domain.)

It is important to note that EPDs are not only for construction materials, although construction materials are the focus of EO 14,057. EPDs are created for all varieties of goods and services. Figure 11 shows the environmental impacts of the Italian apple.

ENVIRONMENTAL IMPACT INDICATORS		UNIT OF MEASURE	UPSTREAM		CORE			DOWNSTREAM		TOTAL
			Agricultural input production	Raw materials production	Field phase	Plant	Packaging	Distribution	Packaging end of life	
Global Warming Potential (GWP)	fossil	kg CO_2 eq	9,06E-03	1,69E-03	3,51E-02	5,12E-03	8,07E-03	4,31E-02	9,55E-05	**1,02E-01**
	biogenic	kg CO_2 eq	4,53E-06	6,14E-05	0,00E+00	1,09E-03	1,88E-05	1,87E-06	1,62E-03	**2,80E-03**
	land use and land use change	kg CO_2 eq	5,40E-06	7,80E-05	0,00E+00	3,58E-07	9,75E-06	3,77E-07	2,97E-10	**9,39E-05**
	TOTAL	kg CO_2 eq	9,07E-03	1,83E-03	3,51E-02	6,22E-03	8,10E-03	4,31E-02	1,72E-03	**1,05E-01**
Acidification potential, AP		kg SO_2 eq	6,96E-05	4,94E-06	6,60E-04	1,55E-05	5,59E-05	3,11E-04	2,92E-07	**1,12E-03**
Eutrophication potential, EP		kg PO_4^{3-} eq	6,97E-06	2,01E-06	8,84E-04	1,93E-06	1,03E-05	3,48E-05	1,39E-06	**9,42E-04**
Photochemical oxidation potential, POFP		kg NMVOC eq	2,84E-05	4,12E-06	4,02E-04	1,44E-05	2,11E-05	2,76E-04	8,93E-07	**7,47E-04**
Abiotic impoverishment potential - elements		kg Sb eq	1,77E-07	2,49E-10	0,00E+00	7,73E-11	3,66E-09	1,69E-09	5,92E-13	**1,83E-07**
Abiotic impoverishment potential - fossil fuels		MJ, net calorific value	5,40E-01	7,83E-02	0,00E+00	7,92E-02	2,47E-01	5,97E-01	2,15E-04	**1,54E+00**
Water scarcity		m^3 eq	2,12E+00	3,20E-01	0,00E+00	4,57E-05	4,52E-03	0,00E+00	9,03E-03	**2,45E+00**

Figure 11. The environmental impacts of Italian apples (Assomela 2023).

EPD USE CASES: Although EPDs were primarily intended to be used in business-to-business transactions, they are now being used to benefit consumers focused on the environment. EPDs can be used to meet decarbonization goals and to obtain LEED credit. They are also being required as part of state and other public-sector policy regarding buying clean, lower-carbon materials for construction. Following the 2022 Inflation Reduction Act, several federal agencies have been working towards lower levels of embodied carbon in construction materials using EPDs. Even before national use, however, EPDs were being used at an international level.

EPD use to meet decarbonization goals. The most effective means to reducing carbon emissions, or practicing decarbonization, is to holistically analyze and understand the target carbon footprint. A carbon footprint can be broken down into three scopes of emissions.

- Scope 1: These are on-site emissions generated by sources controlled or owned by an organization. Examples include fuel combustion from boilers, furnaces, and vehicles.
- Scope 2: These are GHG-related emissions that occur off-site resulting from energy use.
- Scope 3: These are all emissions not included in Scope 1 and 2 categories and result from operations by assets owned and operated by entities other than the organization but impact the organization indirectly through its value chain (EPA 2022). Embodied carbon of construction materials is a significant contributor of Scope 3 emissions, as well as the GHG emissions from activities associated with building materials (i.e., manufacturing, transportation, installation, maintenance, and disposal) (CLF 2020).

EPDs can play a key role in helping organizations define their emissions baseline and pinpoint hotspots throughout the value chain. Using products with EPDs allows organizations to better understand the carbon impacts of their procurement decisions.

EPD use in LEED. The US Green Building Council's (USGBC) LEED green building rating system contains one credit involving EPDs (USGBC 2020). Understanding EPD use in the LEED rating system is beneficial for two reasons. First, Army new construction projects are required to achieve LEED silver certification, and understanding each available credit helps project teams plan to meet this requirement (ASA IE&E 2017). Second, USGBC is a green building industry leader, and understanding their plans for using EPDs provides insight on present and future EPD use in the green building industry. The LEED v4 credit incorporating EPDs is found in the "Materials and Resources" category and is named "Building Product Disclosure and Optimization—Environmental Product Declarations."

For one point, projects must use 20 products with a type III EPD or products with a critically reviewed, product-specific LCA from at least five manufactures. Eligible products include the following:

- Products with publicly available, critically reviewed LCA conforming to ISO 14044
- Products with a product-specific, type III EPD that has been internally reviewed
- Products with an industry-wide, type III EPD
- Products with a product-specific, type III EPD that has been third-party certified (valued as 1.5 products)

This LEED v4 credit accepts all type III EPDs as well as products with a critically reviewed LCA. Because the highest standard for EPDs is a third-party-certified, product-specific, type III EPD, those products are weighted to count as 1.5 products for this credit. This credit reflects the current market for EPDs, where finding and acquiring products with EPDs is the first major challenge to be addressed. Part of the intent of this credit is to drive market demand for products with EPDs and to get project teams familiarized with EPDs.

There is currently no credit in the LEED v4 rating system for applying EPDs, but this will likely be a future step once the use of EPDs becomes more widespread. An example of a potential future application of EPDs can be found in the LEED pilot credit "Procurement of Low Carbon Construction Materials." Pilot credits are a way for USGBC to test out potential new credit additions to the LEED rating system and count towards the "Innovation" credit category. This pilot credit involves two steps. Step 1 asks projects to create a baseline calculation of the building embodied carbon intensity. To do this, project teams would use material embodied carbon intensity baselines published by the University of Washington in conjunction with the Carbon Leadership Forum. Step 2 asks project teams to calculate their actual building embodied carbon intensity using material EPDs. The project team would then compare the baseline and actual embodied carbon intensity to show a verified reduction in embodied carbon. At present, this pilot credit would be considered difficult to achieve, but it provides an example of how EPDs could be used in the future. The next version of LEED, LEED v5, will be focused on driving action to reduce embodied carbon

in buildings to align projects with the Paris Climate Accord's 2030 and 2050 targets (USGBC n.d.).

EPDs in public policy. As of April 2022, three states have legislated green public purchasing in which EPDs are required as part of the Buy Clean policies. These states are Colorado, California, and Oregon. Although only three states have legislated Buy Clean policies, several other states have drafted policy on the subject. Figure 12 shows a map of the United States calling out those states in various stages of implementing Buy Clean policy.

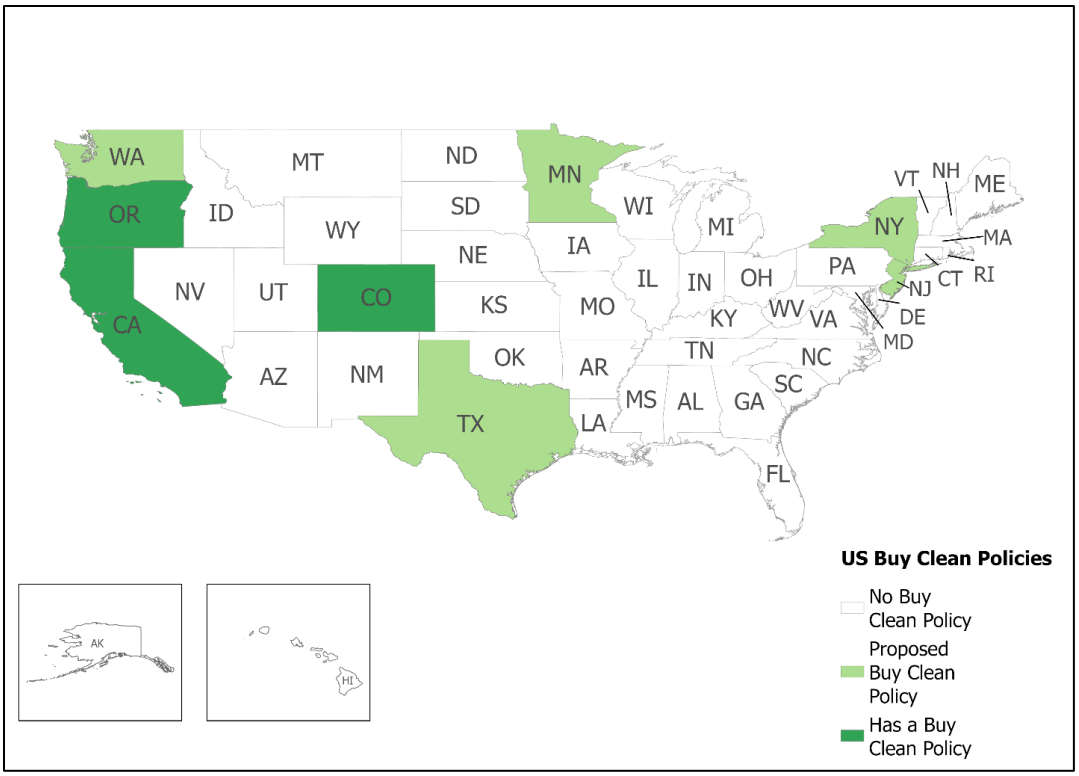


Figure 12. Map of US states and related Buy Clean policies as of April 2022.

Procurement policies have different standards "on the type of EPD required; existing and proposed legislation require facility-specific, product-specific, or supply-chain-specific EPDs. Facility-specific and supply-chain-specific EPD requirements were introduced by policymakers interested in upstream data that have not yet been included in the minimum requirements established by the PCR for an eligible product" (Lewis et al. 2021). Table 5 offers pros and cons for using different classifications of EPDs in policy.

Table 5. Pros and cons of different EPDs in policy. (Reprinted with permission from Lewis et al. 2021.)

Classification of EPD	Pros (for use in policy)	Cons (for use in policy)
Supply-chain-specific Product-specific EPD that uses supply-chain-specific (primary) data to model the impacts of key upstream processes (e.g., contribute >80% relative impact)	More accurately represents impacts of products with large upstream impacts Appropriate for use across product types without identifying additional requirements (e.g., requires additional data only where significant), thereby reducing burden on manufacturers Incentivizes sustainable sourcing and supply-chain transparency	Less widely available Guidance not yet available for manufacturers in PCRs
Product-specific Represent the impacts for a specific product and manufacturer across multiple facilities	More commonly available, thereby reducing burden on manufacturers to create new EPDs Appropriate for use across product types	Requires PCRs to be updated to include key data PCRs are slow to update and may not require key upstream supply-chain data quickly enough to meet policy goals
Facility-specific Product-specific EPD in which the environmental impacts can be attributed to a single manufacturer and manufacturing facility	More accurately represents impacts of products sourced from a specific facility (e.g., grid mix, production methods, etc.) if impacts are concentrated in a single facility	Less widely available Incentivizes manufacturers to focus decarbonization efforts to only one facility Appropriate for use only for products where the majority of impacts are at a single facility, rather than spread across a supply chain Requires policymakers to set new EPD requirements as additional materials are required

Buy Clean Colorado Act. In July 2021, the state of Colorado approved the Buy Clean Colorado Act to establish a maximum acceptable global warming potential (GWP) limit for certain eligible materials as identified in the act (CoDPA, n.d.). In order to establish benchmarks for future carbon-conscious sustainable materials, the state of Colorado currently requires EPDs without specifying minimum criteria. The EPDs currently being collected will be used to establish benchmarks for future requirements. The state's standard specifications now include definitions for EPDs, PCRs, and product categories, as well as establishing EPD submittal requirements. The submittal requirements are further detailed in Appendix O of the *Field Materials Manual* of the Colorado Department of Transportation (CDOT).

This policy targets the reduction of GHGs and climate change impacts on state public projects exceeding $500,000, with a solicitation date on or after 1 January 2024 (CoDPA, n.d.).

The state determined a list of materials as the focus of the Buy Clean Colorado Act due to high carbon emissions impacts and the sheer volume of the materials used in public projects (CoDPA, n.d.). Below is the list of eligible items:

- Asphalt and asphalt mixtures
- Cement and concrete mixtures
- Glass
- Post-tension steel
- Reinforcing steel
- Structural steel
- Wood structural elements

For an EPD to be accepted and approved as part of the Buy Clean Colorado Act, the following must be true:

- EPD must be a current product-specific, type III EPD
- All ISO Standards (ISO 14025:2006, ISO 14040:2006, ISO 14044:2006, and ISO 21930:2017 or EN 15804) must be referenced
- EPD alignment with applicable PCR requirements

Buy Clean California Act. In 2017, the BCCA was "enacted to target carbon emissions specific to the production of structural steel, concrete reinforcing steel, flat glass, and mineral wool board insulation" (State of California 2023). State awarding authorities were designated responsible for ensuring that the materials do not have a GWP that exceeds limits set by the state's Department of General Services (DGS) when used in public works projects (DGS 2022).

An analysis of several factors was completed to establish GWP limits. A decision for each aspect was made to finalize the methodology and establish those limits. The list below highlights the decisions made:

- Review of available PCRs for the eligible materials. Those PCRs reviewed were intended for products used and sold in North America.
- Division of eligible materials into subcategories based on similarity of manufacturing, materials, or function. A total of seven GWP limits were established for the four eligible material categories:
  - Structural steel: Hot-rolled sections
  - Structural steel: Hollow structural sections
  - Structural steel: Plate
  - Concrete-reinforcing steel
  - Flat glass
  - Mineral wool board insulation: Light density
  - Mineral wool board insulation: Heavy density

- Review of life-cycle stages and impact assessment in the production stage only
- Exclusion of emissions due to fabrication for all eligible materials

Utilizing the information above, DGS established limits using either mathematically calculated averages of reported GWP from only facility-specific EPDs or leveraging the reported GWP from an industry-wide EPD (DGS 2022). Table 6 provides the maximum acceptable GWP limits for unfabricated and fabricated products for each subcategory of eligible material.

Table 6. State of California unfabricated and fabricated global warming potential (GWP) limits (recreated from DGS 2023).

Eligible Material	Maximum Acceptable GWP Limit* for Unfabricated Product (Cradle-to-Gate)†	Maximum Acceptable GWP Limit* for Fabricated Product (A1 Module Only)‡
Hot-rolled structural steel sections	1,010 kg CO_2 eq.** or 1.01E+03 kg CO_2 eq. for one metric ton of structural steel	1,080 kg CO_2 eq. or 1.08E+03 kg CO_2 eq. for one metric ton of structural steel
Hollow structural sections	1,710 kg CO_2 eq. or 1.71E+03 kg CO_2 eq. for one metric ton of structural steel	1,830 kg CO_2 eq. or 1.83E+03 kg CO_2 eq. for one metric ton of structural steel
Steel plate	1,490 kg CO_2 eq. or 1.49E+03 kg CO_2 eq. for one metric ton of structural steel	1,590 kg CO_2 eq. or 1.59E+03 kg CO_2 eq. for one metric ton of structural steel
Concrete reinforcing steel	890 kg CO_2 eq. or 8.90E+02 kg CO_2 eq. for one metric ton of structural steel	920 kg CO_2 eq. or 9.20E+02 kg CO_2 eq. for one metric ton of structural steel
Flat glass	1,430 kg CO_2 eq. or 1.43E+03 kg CO_2 eq. for one metric ton of structural steel	N/A
Light-density mineral wool board insulation	3.33 kg CO_2 eq. for 1 m^2 of insulation at R_{SI} = 1††	N/A
Heavy-density mineral wool board insulation	8.16 kg CO_2 eq. for 1 m^2 of insulation at R_{SI} = 1	N/A

* GWP limit based on a 100-year lifetime impact.
† Use this column to determine compliance when an EPD declares unfabricated-product GWP. Compare manufacturer cradle-to-gate GWP to the limit.
‡ Use this column to determine compliance when an EPD declares fabricated product GWP. These limits are derived from the unfabricated product GWP and account for the waste in the fabrication process.
** Kilogram carbon dioxide equivalent.
†† Thermal resistance (R_{SI}) with a value of 1 m^2K/W (square meters × degrees Kelvin per watt).

Because GWP limits have been set by the State of California, awarding authorities now require, review, and accept a manufacturer's single-facility EPD for compliance (DGS 2023).

Buy Clean Oregon Act. The Buy Clean Oregon Act was signed into law in March 2022.

The law targets GHGs within the state's Department of Transportation by requiring the establishment of a pilot program that assesses how procured products affect carbon dioxide emissions (Oregon State Legislature 2022).

This program for GHG reduction must be established by 31 December 2025.

Other public-sector EPD uses. Additionally, several jurisdictions across the US have programs to develop baseline climate impacts of concrete vendor mixes and are requiring EPDs to be submitted with material delivery. "These programs include the City of Portland, Oregon; Caltrans (California Buy Clean); Sound Transit (Washington); Colorado DOT; Minnesota DOT; Illinois Turnpike Authority; and Port Authority of New York and New Jersey (PANYNJ)" (Good Company, n.d.). Their initial steps can provide insight on how to move forward with DoD-wide implementation of EPDs. See Table 7 for public-sector legislation on EPD requirements.

Table 7. Overview of EPD requirements in existing and proposed legislation focused on embodied carbon. (Reproduced with permission from Lewis et al. 2021.)

Year Introduced	Source	Bill	Type of EPD Required
2017	California Legislature	Buy Clean California Act	Type III, facility-specific EPD
2019	City of Portland	New requirements for concrete	Type III, product-specific EPD
2019	Minnesota Legislature	HF 2204	Type III, facility-specific EPD
2020	New York State Senate	S542 (Original)	Type III, product-specific EPD
2021	California Legislature	AB-1365, SB-778	Type III, supply-chain-specific EPD that "makes use of supply chain-specific data for input materials whenever this data is available"
2021	Colorado State Assembly	HB 21-1303	Type III EPD
2021	Oregon State Legislature	HB 2688	"Product-specific measurement of the life cycle environmental impact of a product, from the point of raw material extraction to the point of manufacture, that is certified by a third party and in accordance with international standards"
2021	New Jersey Assembly	AB 5223	Type III, product-specific EPD
2021	Washington State Legislature	HB 1103	Type III, supply-chain-specific EPD
2021	House of Representatives, 117th Congress	H.R.1512 CLEAN Future Act—Subtitle C—Federal Buy Clean Program	Type III, product-specific EPD "calculated for a specific facility"

How federal agencies are integrating EPDs. President Biden signed the Inflation Reduction Act into law on 16 August 2022, allocating $370 billion in investments. Of the $370 billion, $350 million was earmarked for "grants, technical assistance, and tools . . . to help . . . measure, report, and substantially lower the levels of embodied carbon and other greenhouse gas emissions associated with [the] production, use and disposal of construction materials and products" (EPA 2023). Although this money was tasked to the Pollution Prevention Program of the Environment

Protection Agency (EPA), many federal agencies have been working towards lower levels of embodied carbon in construction materials.

Environmental Protection Agency (EPA). To support the $350 million effort, the EPA issued a request for public comment related to the development of these programs. The request for information, issued in January 2023 and ending in May 2023, was accompanied by three public engagement webinars.

The EPA website is a way to stay informed on the EPA's research and implementation of EPDs.[2]

Federal Highway Administration (FHWA). In 2016, the FHWA was already exploring the use of EPDs and drafted a potential three-stage implementation plan and roadmap for agencies interested in encouraging EPDs. The three stages included in this road map were as follows:

- Stage 1: Establish an EPD database and encourage the use of EPDs by providing incentives. Use pilot projects to request EPDs to refine the specifications and help develop tools that utilize EPDs. This stage was anticipated to be in place for one to two years before moving on to the next stage.
- Stage 2: Standardize PCRs. This stage focuses on the development procedures and reporting practices, using PCRs created or reviewed by a committee of stakeholders. The roadmap indicated this phase should be active for three to five years before beginning the final stage.
- Stage 3: Utilize EPDs in procurement and design. After a database has been established and PCRs standardized, EPDs can be used to inform selection between materials. The EPDs can also be used to quantify agency averages and as a data source for LCAs.

Per the FHWA, there are multiple potential uses for EPDs. Figure 13 shows both current uses for EPDs and the FHWA's recommended path forward for EPDs.[3]

2. This information can be found at https://www.epa.gov/inflation-reduction-act/inflation-reduction-act-programs-fight-climate-change-reducing-embodied.

3. Additional information regarding the FHWA plan can be found at https://www.fhwa.dot.gov/innovation/everydaycounts/edc_7/sustainable_epds.cfm - :~:text=EPDs%20communicate%20the%20greenhouse%20gas%20%28GHG%29%20emissions%20of,environmental%20impacts%20by%20transforming%20the%20project%20delivery%20process.

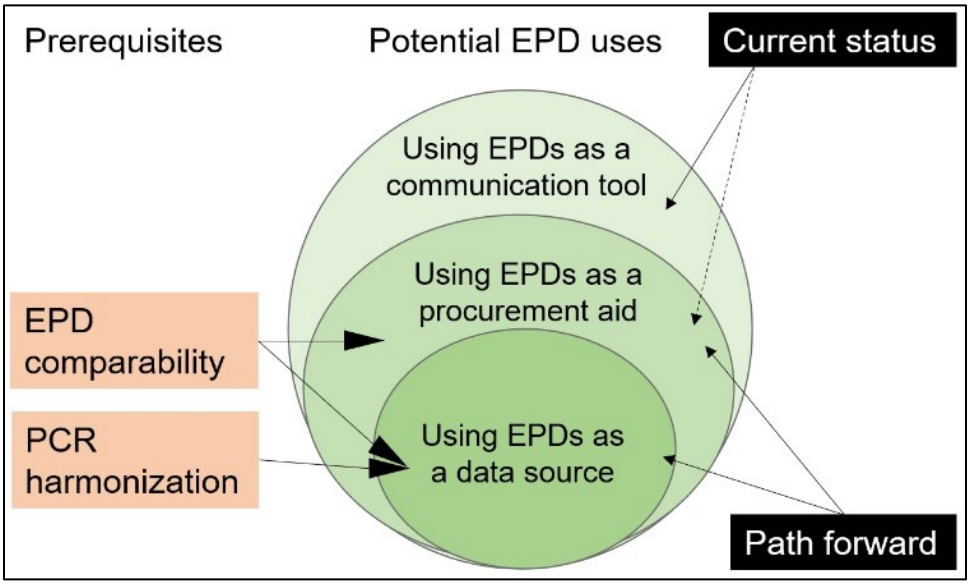


Figure 13. Potential uses of EPDs (Rangelov et al. 2021).

General Services Administration (GSA). Although GSA began requiring the use of EPDs for a material approach on small projects in September 2021, the major shift in GSA occurred in early 2022.

In March 2022, GSA set standards for low embodied carbon concrete and environmentally preferable asphalt. These new national standards apply to both capital and small GSA projects awarded through construction contracts. Per GSA, these national standards are the first in the United States to apply beyond state and local jurisdiction (GSA 2022).

At this time, the standards require construction contractors to provide EPDs for low embodied carbon concrete, where available. Contractors must also use concrete that reflects a 20% reduction in the amount of GHG emissions from the national concrete GHG limits (GSA 2022). For asphalt, EPDs must be submitted along with at least two environmentally preferable techniques or practices that will be used during the manufacturing or installation process (GSA 2022).

Currently, GSA is testing the March 2022 standards through pilot projects.[4]

International Use of EPDs and trends for future use. Many countries in Europe have been ambitiously studying how to reduce environmental footprints by incentivizing or requiring organizations to communicate accurate environmental impacts, with an eye toward more comprehensive sustainability impacts (including social impacts). In February 2001, the European Commission published the *Green Paper on Integrated Product Policy* (IPP) that identifies

4. More information regarding the new standards can be found on the GSA website at https://www.gsa.gov/real-estate/design-and-construction/engineering-and-architecture/facilities-standards-p100-overview.

product-related goals, most significantly, providing clear, credible, and easily obtainable information that will increase the use of greener products.

To better understand how to accomplish this, the European Commission worked with stakeholders from countries with EPD programs (Italy, Sweden, Denmark and Finland). This collaboration resulted in a study focused on comparing national and sectoral EPD schemes to further standardization and identify applications of use with other IPP tools.

The Commission then worked with a wide range of industry and subject-matter experts (SMEs) to further enhance and update product-specific rules for minimizing environmental footprints. Important development includes guidelines on the approach to incorporating biodiversity and improving methods for assessing impacts on human health and the environment (European Commission, 2003*).*

Commissioner for Environment, Fisheries, and Oceans Virginijus Sinkevičius said the following about the interest in and purpose of environmental footprint methods in Europe: "The EU Environmental Footprint methods are the most reliable, comparable and verifiable way to know the real environmental footprint of a product or organisation to date. Europeans are increasingly aware of their own environmental footprint, and many want to make environmentally friendly choices in their daily lives. These methods will help to improve environmental performance and help achieve a truly clean and circular economy" (Directorate-General for Environment 2021).

Aligning with the Commission's work on environmental impacts from products and organizations are several key policies and plans outlined below:

- *The European Green Deal*: The goal of this policy is to support industries in creating a clean and circular economy. It emphasizes the need for reliable and comparable information to reduce "green washing" and increase opportunities for consumers to make more educated sustainable procurement decisions.
- *A New Circular Economy Action Plan—For a Cleaner and More Competitive Europe:* The plan highlights that product and environmental footprint methods need to be used by companies to verify environmental claims.
- *New Consumer Agenda—Strengthening Consumer Resilience for Sustainable Recovery.* The outline of the Commission's plans to work with economic stakeholders to encourage companies to provide transparency of product environmental footprints.
- *Taxonomy Regulation*, the *Sustainable Batteries Initiative,* and the *Green Consumption Pledge:* These documents provide opportunities for employing environmental footprint methods.[5]

5. "Commission Recommendation (EU) 2021/2279 on the Use of the Environmental Footprint Methods to Measure and Communicate the Life Cycle Environmental Performance of Products and Organisations. 2021 O.J. (L 471) 1. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32021H2279&from=EN.

These collaborative planning practices and resulting plans and policies used in Europe can provide examples to the rest of world on how to approach reducing the environmental footprint of products through stakeholder engagement in voluntary action, economic and market incentivization, and government regulation, policies, and guidelines.

CHALLENGES AND FUTURE EFFORTS NEEDED TO ASSESS EPDS: As the demand for EPDs increases, there is a growing need to ensure that EPDs are transparent, accurate, and reliable.[6] Ensuring the quality of EPDs is important for the viability of using EPDs to inform and compare procurement decisions and project LCAs. Quality EPDs will be conformant to ISO standards, consistent with LCA best practices, and formatted in a way that enables digital communication with construction, accounting, and other reporting tools (Bhat et al. 2022) The EPA has identified the following challenges in enhancing the transparency and standardization of EPDs:

- How the EPD was created (i.e., which specific tool and datasets utilized)
- Units of measure
- Specificity of environmental impacts (i.e., industry wide, facility specific, manufacture specific)
- Format
- Life-cycle stages (EPA Office of Chemical Safety and Pollution Prevention 2023)

The EPA will seek to address these challenges as they implement their Inflation Reduction Act programs.

Procurement policies such as the Federal Buy Clean Initiative will impact the future of EPDs. The Carbon Leadership Forum (CLF), a leading organization in embodied carbon work, has made recommendations for the role of policymakers in supporting the Federal Buy Clean Act. Specifically,

> Policymakers may consider one of the following strategies to encourage harmonization and allow for the addition of eligible materials over time:
>
> - Request supply chain–specific EPDs with additional life-cycle stages beyond the product stage, including material extraction and processing, transportation of the materials, and manufacturing of the product.
>
> - Require product-specific EPDs and participate in PCR development to encourage the inclusion of upstream data and additional life-cycle stages in PCRs. (Lewis et al. 2021)

6. Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability. Exec. Order No. 14,057, 86 Fed. Reg. 70935–70943 (Dec 8, 2021). https://www.federalregister.gov/documents/2021/12/13/2021-27114/catalyzing-clean-energy-industries-and-jobs-through-federal-sustainability.

Another opportunity to advance EPDs is by improving the creation and execution of PCRs. As the framework for creating and managing EPDs, increasing PCR standardization and transparency would go a long way in improving overall EPD quality and usability. Some PCR challenges to be addressed include that they vary in the background datasets, the methods for primary data collection, and how they provide access to underlying LCAs. Since PCRs provide the guidance for conducting the LCA and creating EPDs, insufficient guidance could lead to inconsistencies between EPDs from the same program.

One PCR standardization effort is the PCR Guidance Development Initiative led by the American Center for Life Cycle Assessment (ACLCA). This 2013 initiative involved a global effort from individuals across over 40 different organizations with the goal of supplementing existing standards to ensure that PCRs can be developed consistently and used to support claims based on multiple standards (Ingwersen and Subramanian 2013). In 2022, the ACLCA supplemented the PCR guidance with the release of a North American–specific PCR guidance and toolkit for creating standardized, consistent, and reliable PCRs and EPDs for transparency, procurement, and supply-chain data (Bhat et al. 2022). This guidance aims to improve PCRs by providing checklists for each of the three entities involved in the PCR process: program operators, PCR committees, and PCR review panels. Although this guidance represents best practices for the PCR process, compliance with the guidance is not currently mandated.

TRENDS MOVING FORWARD The communication value of the concisely recorded environmental impact data within an EPD has been widely acknowledged. Current efforts largely focus on increasing standardization and transparency of EPDs. The next logical step in this effort is to establish a primary authority to collect, store, and maintain a centralized EPD data repository. This would be the first step in improving automation, accessibility, and integrating EPDs into multidisciplinary workflows. A core benefit of product declarations is the potential to influence the market, and therefore, create a positive impact on carbon emissions through Buy Clean initiatives. The development of a centralized tracking system only stands to increase the accuracy and utility of EPDs across multiple markets. The current state of EPD development and storage makes tracking changes to EPDs difficult. A relatively short EPD life-span requires that it be reevaluated approximately every five years depending on its PCR guidelines. A current issue is that should an EPD expire it can no longer be used in the creation process of new EPDs. Therefore, it is imperative that the expiration of an EPD be tracked closely.

The National Institute of Building Sciences (NIBS) is a nongovernment not-for-profit focused on ensuring that buildings are “safe, structurally sound, and sustainable” (NIBS, n.d.). The unique position of NIBS allows it to provide industry-advancing information to SMEs in the architect, engineer, and contractor (A/E/C) profession in both the public and private sector. At the moment, they host a number of tools that provide up-to-date and relevant research and best practices when designing buildings. Tools such as the Whole Building Design Guide, and the Building Research Information Knowledgebase showcase the potential that NIBS has for hosting an additional data repository focusing on EPDs. Additionally, the membership roster of NIBS spans multiple branches of the military and government bodies, reinforcing the idea that EPDs would be highly visible throughout the industry. A potential future path is the development and deployment of an advanced EPD repository that can integrate the data from previously existing repositories and act as a centralized resource for future EPD utilization and development.

SUMMARY: EPDs have been used across the world for at least 25 years, with growing interest in their use to minimize negative human and environmental impacts from products, specifically carbon footprints in the construction industry. As a disclosure document, the EPD is now the standard method for identifying and comparing impacts of materials throughout their life cycle in the construction industry. EPDs can provide the necessary environmental impact data needed to inform procurement decision-making that aligns with the Buy Clean Initiative and Executive Order 14,057, which aim to promote the use of sustainable construction materials and achieve net-zero emissions during procurement.

EPDs are currently being used in Buy Clean policy and law at the state and local levels, as well as within other public-sector policies. Furthermore, through the Inflation Reduction Act and other programs, federal agencies are further exploring and integrating EPDs into design, purchase, and construction requirements. It can be expected that this investment into EPD research and increases in market demand for products with EPDs will increase the availability of products with an EPD and improve the quality and consistency of EPD programs. As the federal government looks to utilize EPDs in its policies, there could be an opportunity to learn from and collaborate with state and international partners who are also working in this space.

A continued effort towards standardization and transparency of EPDs is necessary to meet the goal of utilizing EPDs to compare and select materials. One approach to do this could be through the establishment of a primary authority to coordinate EPD standards and guidance and collect, store, and maintain a centralized EPD data repository. For example, the European Commission is working to develop a directory of easily accessible LCA databases that could provide accurate and updated information for development product declarations. (European Commission 2003). These kinds of public repositories could assist in correcting the lack of uniformity that currently exists and make it easier to create and use EPDs.

ADDITIONAL INFORMATION: This technical note should be cited as follows:

> Fuhler, Megan R., Brent D. Panozzo, Birgitte R. Dodd, Dylan A. Pasley, and Allison R. Young. 2023. *The Importance of Environmental Product Declarations in the Decarbonization Effort*. ERDC/CERL TN-23-1. Champaign, IL: US Army Engineer Research and Development Center, Construction and Engineering Research Laboratory.

BIBLIOGRAPHY

AIA (American Institute of Architects). 2018. "Environmental Product Declaration (EPD)." The American Institute of Architects, April 13, 2018. https://www.aia.org/articles/168751-environmental-product-declaration-epd.

ASA IEE (Assistant Secretary of the Army for Installations, Energy and Environment). 2017. *Sustainable Design and Development Policy Update*. Washington, DC: Department of the Army. https://www.wbdg.org/FFC/ARMYCOE/POLICY/Army_SDD_Policy_Update_2017.pdf

ASMI (Athena Sustainable Materials Institute). n.d. "LCA, LCI, LCIA, LCC: What's the Difference?" Accessed May 17, 2023. http://www.athenasmi.org/resources/about-lca/whats-the-difference/.

Assomela. 2023. "Environmental Product Declaration of Italian Apples." The International EPD System, Last revised May 4, 2023. https://api.environdec.com/api/v1/EPDLibrary/Files/a623234a-5707-4c63-70fc-08db473a5587/Data.

Bhat, C. G., T. Adhikari, J. Mellentine, R. Feraldi, A. Lasso, T. Swack, A. Mukherjee, H. Dylla, M. Rangelov. 2022. *2022 ACLCA PCR Guidance—Process and Methods Toolkit*. Version 1.0. American Centre for Life Cycle Assessment. https://aclca.org/wp-content/uploads/2022-ACLCA-PCR-Guidance_v1_Introduction_05252022.pdf.

Boguski, T., and A. Ganzert. 2020. "Environmental Product Declaration (EPD) 101." American Center for Life Cycle Assessment. May 3, 2020. YouTube video, 27:11. https://www.youtube.com/watch?v=Mk3OLVCtXvA&t=183s.

Building Transparency. n.d. "How to Get an EPD." Accessed March 8, 2023. http://www.buildingtransparency.org/resources/how-get-epd/.

Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability. Exec. Order No. 14,057, 86 Fed. Reg. 70935–70943 (Dec 8, 2021). https://www.federalregister.gov/documents/2021/12/13/2021-27114/catalyzing-clean-energy-industries-and-jobs-through-federal-sustainability.

CLF (Carbon Leadership Forum). 2020a. *Embodied Carbon 101*. Carbon Leadership Forum. December 17. https://carbonleadershipforum.org/embodied-carbon-101/.

CLF. 2020b. *Guidance on Embodied Carbon Disclosure*. Carbon Leadership Forum. December 17. https://carbonleadershipforum.org/guidance-on-embodied-carbon-disclosure/.

CoDPA (Colorado Department of Personnel and Administration). n.d. "Buy Clean Colorado Act." Accessed April 25, 2023. https://osa.colorado.gov/energy-environment/buy-clean-colorado-act.

"Commission Recommendation (EU) 2021/2279 on the Use of the Environmental Footprint Methods to Measure and Communicate the Life Cycle Environmental Performance of Products and Organisations." 2021 O.J. (L 471) 1. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32021H2279&from=EN.

DGS (Department of General Services, California). 2022. *Buy Clean California Act Legislative Report*. Sacramento, CA: Department of General Services. https://www.dgs.ca.gov/Resources/Legislative-Reports.

DGS. 2023. "Buy Clean California Act Environmental Product Declaration (EPD) Compliance Guide." Last updated February 22, 2023. https://www.dgs.ca.gov/PD/Resources/Page-Content/Procurement-Division-Resources-List-Folder/Buy-Clean-California-Act.

Directorate-General for Environment. 2021. Environmental Footprint Methods." *European Commission*, December 16, 2021. https://environment.ec.europa.eu/news/environmental-footprint-methods-2021-12-16_en.

Dvecheve. 2019. "EDP Steps Framework." Wikimedia Commons. https://commons.wikimedia.org/wiki/File:EDP_steps_framework.png.

EPA (United States Environmental Protection Agency). 2023. "Inflation Reduction Act Programs to Fight Climate Change by Reducing Embodied Greenhouse Gas Emissions of Construction Materials and Products." Last updated June 1, 2023. https://www.epa.gov/inflation-reduction-act/inflation-reduction-act-programs-fight-climate-change-reducing-embodied.

EPA Center for Corporate Climate Leadership. 2022. "Scope 1 and Scope 2 Inventory Guidance." EPA. Last updated September 9, 2022. https://www.epa.gov/climateleadership/scope-1-and-scope-2-inventory-guidance.

EPA Office of Chemical Safety and Pollution Prevention. 2023. *Getting to Substantially Lower Embodied Greenhouse Gas Emission Construction Materials: Material Prioritization and Data Improvement*. Slide presentation, Inflation Reduction Act Stakeholder Engagement, March 2, 2023. https://www.epa.gov/system/files/documents/2023-04/FINALv3%20March%202%20-%20OCSPP%20IRA%20Programs%20-%20Material%20Prioritization%20and%20Data%20Improvement%20ec.pdf.

EPD Australia. 2023. "25th Anniversary of EPD: Remembering the First EPD for Hydro Electricity Production." March 14, 2023. https://epd-australasia.com/2023/03/25th-anniversary-of-epd-remembering-the-first-epd-for-hydro-electricity-production/.

EPD International. n.d. "What is an ..... E ..... P ..... D ..... (morse?)." Accessed August, 14, 2023. https://www.environdec.com/all-about-epds/the-epd.

European Commission. 2003. "Communication from the Commission to the Council and the European Parliament—Integrated Product Policy—Building on Environmental Life-Cycle Thinking." Document 52003DC0302. European Union, Directorate-General for Environment. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52003DC0302.

Feng, H., J. Zhao, A. Hollberg, and G. Habert. 2023. "Where to Focus? Developing a LCA Impact Category Selectino Tool for Manufacturers of Building Materials." *Journal of Cleaner Production* 405 (June):136,936. https://doi.org/10.1016/j.jclepro.2023.136936.

FHWA (Federal Highway Administration). 2023. "Environmental Product Declarations (EPDs) for Sustainable Project Delivery." Last updated February 2, 2023. https://www.fhwa.dot.gov/pavement/sustainability/epds/what/.

Good Company. n.d. *Environmental Product Declarations*. Oregon DOT (Department of Transporation). Accessed August 22, 2023. https://www.oregon.gov/odot/climate/Documents/EPDs_InfoSheet-ODOTghginventory.pdf.

Graves, R., G. Mosiman, and E. Kutschke. 2022. *Construction Materials:Environmental Impact Study*. Center for Sustainable Building Research, University of Minnesota. https://www.lrl.mn.gov/docs/2022/mandated/220176.pdf.

GSA (General Services Administration). 2022. "GSA Lightens the Environmental Footprint of its Building Materials." March 30, 2022. https://www.gsa.gov/about-us/newsroom/news-releases/gsa-lightens-the-environmental-footprint-of-its-building-materials-03302022.

Ingwersen, W., and V. Subramanian, eds. 2013. *Guidance for Product Category Rule Development*. Cincinnatti, OH: The Product Category Rule Guidance Development Initiative. https://cfpub.epa.gov/si/si_public_record_report.cfm?dirEntryId=259406&Lab=NRMRL.

ISO (International Organization for Standardization). 2006. *Environmental Labels and Declarations—Type III Environmental Declarations—Principles and Procedures*. International Organization for Standardization. https://www.iso.org/obp/ui/#iso:std:iso:14025:ed-1:v1:en.

Lewis, M., M. Huang, B. Waldman, S. Carlisle, and K. Simonen. 2021. *Environmental Product Declaration Requirements in Procurement Policies.* Seattle, WA.: Carbon Leadership Forum, University of Washington. https://carbonleadershipforum.org/epd-requirements-in-procurement-policies/.

NIBS (National Institute of Building Sciences). n.d. "Our Story." https://www.nibs.org/about.

PCA. 2021. *Environmental Product Declaration: Portland Cement*. Skokie, IL: Portland Cement Association. https://www.cement.org/docs/default-source/default-document-library/pca_epd_portland_athena_05042023_final_revised.pdf?sfvrsn=f406febf_2.

PCA (Portland Cement Association). n.d. "PCR, EPDs, and Quantifying the Environmental Impacts of Cement and Concrete." Accessed May 9, 2023. https://www.cement.org/sustainability/pcr-epds.

Rangelov, M., H. Dylla, J. Harvey, J. Meijer, and P. Ram. 2021. *Tech Brief: Environmental Product Declarations: Communicating Environmental Impact for Transportation Products*. FHWA-HIF-21-025. McLean, VA: Federal Highway Administration. https://www.fhwa.dot.gov/pavement/sustainability/hif21025.pdf.

State of California. 2023. "Buy Clean California Act." Department of General Services Procurement Division. Last updated February 8, 2023. https://www.dgs.ca.gov/PD/Resources/Page-Content/Procurement-Division-Resources-List-Folder/Buy-Clean-California-Act.

US Green Building Council. n.d. "LEED v5 Moving Beyond a Movement." Accessed October 16, 2023. https://www.usgbc.org/leed/v5.

US Green Building Council. 2022. *LEED v4.1 Building Design and Construction Guide*. US Green Building Council. https://www.usgbc.org/resources/leed-v41-building-design-and-construction-beta-guide-july-2020.

Wu, Y., and D. Su. 2020. "Review of Life Cycle Impact Assessment (LCIA) Methods and Inventory Databases." In *Sustainable Product Development*, edited by D. Su, 39–55. Cham, Switzerland: Springer Nature. https://doi.org/10.1007/978-3-030-39149-2_3.

APPENDIX: EPD DATABASES

There are many registries for housing Environmental Product Declarations (EPDs). Some of the more common EPD databases are listed below:

- The Embodied Carbon in Construction Calculator (EC3) tool
  - Database of construction EPDs
  - Calculator to determine climate impacts of a building
  - Hosted by Building Transparency
  - EC3 – Login (buildingtransparency.org)
- The EPD Registry
  - Free, searchable online database of EPDs
  - Global reference library with a focus in Europe and the United Kingdom but also has databases in South American and Australia
  - The EPD Registry | Digital EPD | EPD Databases | EPD for World Construction Products and Materials
- ASTM International
  - This database includes a list of project category rules (PCRs) and EPDs.
  - Links to several EPD generators are included on the website.
  - EPDs for specific brands of materials and for general, industry-wide materials can be reviewed.
  - PCRs & EPDs – Environmental Product Declarations – Certification – Products & Services (astm.org)
- Better Materials by US Green Building Council (USGBC) and Green Business Certification Inc. (GBCI)
  - Unified search tool that integrates several existing database search engines, including Spot UL, Origin, Ecomedes, Building Material Scout, and Sustainable Minds Transparency
  - Supports search for environmental documentation needed to achieve LEED's "Materials" and "Resources" credits
  - https://bettermaterials.gbci.org/

There are also registries specific to products. Material-specific EPDs can be found on various sites including the following:

- The National Ready Mixed Concrete Association (NRMCA)
  - Contains a list of EPDs verified under NRMCA's EPD
  - All of the EPDs listed on NRMCA's website are worth full value in LEED v4.
  - Environmental Product Declarations – NRMCA
- American Institute of Steel Construction (AISC)

  - AISC develops industry-wide, third-party-verified EPDs for fabricated hot-rolled structural sections, fabricated steel plate, and fabricated hollow structural sections that can only be used for mill material produced in the United States.
  - Each product applies only to certain manufactures, which are listed on the AISC website.
  - Environmental Product Declarations | American Institute of Steel Construction (aisc.org)
- American Wood Council (AWC)
  - AWC develops industry-wide, third-party-verified EPDs for several types of lumber products, including but not limited to, softwood lumber, glued laminated timber, redwood lumber, and particleboard.
  - AWC also provides a transparency brief for each type of material. These transparency briefs provide a summary of the most critical data presented in an EPD.
  - EPDs & Transparency Briefs – American Wood Council (awc.org)