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Lessons Learned from Caltrans Pilot Program for Implementation of EPDs

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Lessons Learned from Caltrans Pilot Program for Implementation of EPDs

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Partnered Pavement Research Center (PPRC) Project Number 3.47 (DRISI Task 3211):
Support Caltrans with EPDs

PREPARED FOR:

California Department of Transportation
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PREPARED BY:

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16. ABSTRACT

An environmental product declaration (EPD) is a transparent, verified report used to communicate the environmental impacts (e.g., resource use, energy, emissions) associated with the manufacture or production of construction materials such as asphalt, cement, asphalt mixtures, concrete mixtures, or steel reinforcement. EPDs, which are also called Type III Environmental Declarations, are product labels developed by industry in accordance with International Organization for Standardization standards. The scoping document for an EPD, which is also referred to as a product category rule (PCR), defines the requirements for EPDs for a certain product category. Beginning in 2019, Caltrans initiated a pilot study requiring EPDs for hot mix asphalt, aggregates, and concrete in addition to the materials specified by the Buy Clean California Act (BCCA) (Assembly Bill 262). The requirement to submit EPDs for these materials is how plans made several years prior to passage of the BCCA, for use of EPDs to help achieve environmental goals, are being implemented. While the BCCA considers only the greenhouse gas emissions contributing to global warming, the Caltrans pilot program for pavement and bridge materials also looks for other emissions in the EPDs, primarily emissions that cause air pollution. This project consisted of the University of California Pavement Research Center reviewing and helping develop Caltrans's plans for collecting EPDs, reviewing PCRs and EPDs for consistency and inconsistencies, helping to communicate strategy with industries and the Federal Highway Administration, supporting Caltrans's development of a web-based portal for entry of EPD data and the underlying database, and writing of a summary report. This technical memorandum is the summary report. This report documents the roadmaps developed for collecting and using EPDs, other support activities for the Caltrans EPD program, and a review of the EPDs supplied to Caltrans as of the summer of 2020 and their underlying PCRs. The PCRs for the materials in the Caltrans EPD program have inconsistencies that should be relatively simple to resolve with direction from Caltrans. In their current form, consistent data entry is difficult in the Caltrans EPD portal. To improve the consistency and quality of EPDs, Caltrans staff must receive guidance on how to review EPDs, and staff at materials producers require training about how to interpret PCRs to produce EPDs. Systems for inputting data from EPDs into department of transportation (DOT) reporting systems that include data quality checks, system consistency, and certification are also needed. Similarly, a nationally accepted and adopted data quality assessment standard is needed for EPDs as DOTs move toward their use in procurement. A single data quality matrix should also be included in a harmonized PCR.

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7. PROPOSALS FOR IMPLEMENTATION
It is recommended that Caltrans communicate to PCR program operators the need to improve harmonization, that the EPD specifications should be reviewed to require consistent names and units for impact indicators and flows across EPDs and declared units within PCR categories, that Caltrans should develop processes for reviewing submitted EPD data and rejecting data that are clearly incorrect or incorrectly reported, and that Caltrans should develop greater in-house expertise in life cycle assessment.

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PROJECT OBJECTIVES

This study began in the 2014–2017 Partnered Pavement Research Center Strategic Plan Element (PPRC SPE) contract as Project 4.54 (Environmental Life Cycle Assessment Updates and Applications) and continued in the 2017–2020 PPRC contract as Project 3.47 (Support Caltrans with EPDs). The objective of Project 3.47 was to support Caltrans plans and efforts for the implementation of environmental product declarations (EPDs). This was achieved through the following tasks:

1. Review and help develop Caltrans plans for EPDs.
2. Review product category rules (PCRs) and EPDs for consistency and inconsistencies.
3. Help communicate implementation strategy with industries and the Federal Highway Administration.
4. Help build a database in coordination with national efforts.
5. Provide a summary report.

This technical memorandum is the deliverable for Task 5. It presents a summary of the entire project.

LIST OF ABBREVIATIONS

BCCA	Buy Clean California Act
CML	Centrum voor Milieukunde Leiden
DGS	Department of General Services
DIME	Data Interchange for Materials Engineering
EPD	Environmental product declaration
GHG	Greenhouse gas
GWP	Global warming potential
HHV	High heating value
ISO	International Organization for Standardization
LCA	Life cycle assessment
LCI	Life cycle inventory
LHV	Low heating value
MWBI	Mineral wool board insulation
PCR	Product category rule
POCP	Photochemical smog creation potential
SFP	Smog formation potential
SPTG	Sustainable Pavements Task Group
TRACI	Tool for Reduction and Assessment of Chemicals and Other Environmental Impacts

SI* (MODERN METRIC) CONVERSION FACTORS				
APPROXIMATE CONVERSIONS TO SI UNITS				
Symbol	**When You Know**	**Multiply By**	**To Find**	**Symbol**
LENGTH				
in.	inches	25.40	millimeters	mm
ft.	feet	0.3048	meters	m
yd.	yards	0.9144	meters	m
mi.	miles	1.609	kilometers	km
AREA				
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.09290	square meters	m^2
yd^2	square yards	0.8361	square meters	m^2
ac.	acres	0.4047	hectares	ha
mi^2	square miles	2.590	square kilometers	km^2
VOLUME				
fl. oz.	fluid ounces	29.57	milliliters	mL
gal.	gallons	3.785	liters	L
ft^3	cubic feet	0.02832	cubic meters	m^3
yd^3	cubic yards	0.7646	cubic meters	m^3
MASS				
oz.	ounces	28.35	grams	g
lb.	pounds	0.4536	kilograms	kg
T	short tons (2000 pounds)	0.9072	metric tons	t
TEMPERATURE (exact degrees)				
°F	Fahrenheit	(F-32)/1.8	Celsius	°C
FORCE and PRESSURE or STRESS				
lbf	pound-force	4.448	newtons	N
lbf/in^2	pound-force per square inch	6.895	kilopascals	kPa
APPROXIMATE CONVERSIONS FROM SI UNITS				
Symbol	**When You Know**	**Multiply By**	**To Find**	**Symbol**
LENGTH				
mm	millimeters	0.03937	inches	in.
m	meters	3.281	feet	ft.
m	meters	1.094	yards	yd.
km	kilometers	0.6214	miles	mi.
AREA				
mm^2	square millimeters	0.001550	square inches	in^2
m^2	square meters	10.76	square feet	ft^2
m^2	square meters	1.196	square yards	yd^2
ha	hectares	2.471	acres	ac.
km^2	square kilometers	0.3861	square miles	mi^2
VOLUME				
mL	milliliters	0.03381	fluid ounces	fl. oz.
L	liters	0.2642	gallons	gal.
m^3	cubic meters	35.31	cubic feet	ft^3
m^3	cubic meters	1.308	cubic yards	yd^3
MASS				
g	grams	0.03527	ounces	oz.
kg	kilograms	2.205	pounds	lb.
t	metric tons	1.102	short tons (2000 pounds)	T
TEMPERATURE (exact degrees)				
°C	Celsius	1.8C + 32	Fahrenheit	°F
FORCE and PRESSURE or STRESS				
N	newtons	0.2248	pound-force	lbf
kPa	kilopascals	0.1450	pound-force per square inch	lbf/in^2

*SI is the abbreviation for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised April 2021)

1 INTRODUCTION

1.1 Background

Human activity produces emissions to air, water, and/or land—whether it is due to production/manufacturing of goods and energy or to movement/transportation of goods and people—and depletes the finite resources in nature. Making production, transportation systems, and technologies more efficient and sustainable requires quantitative data about their energy use and emissions. With these data, the consequent impacts for these full systems and their complete life cycles can be determined.

A quantitative method for studying environmental and finite resource use impacts is called life cycle assessment (LCA), and recognized standards for performing an LCA have been published by the International Organization for Standardization (ISO) (*1,2).* LCA is a methodology in which a system's environmental impacts and use of finite resources and energy are quantified and analyzed over the full system and its complete life cycle. This analysis can then be translated into damage to the environment, human health, and the availability of resources for future generations *(3,4)*.

An environmental product declaration (EPD) is a transparent, verified report used to communicate the environmental impacts (e.g., resource use, energy, emissions) associated with the manufacture or production of construction materials such as asphalt, cement, asphalt mixtures, concrete mixtures, or steel reinforcement. EPDs, also called Type III Environmental Declarations, are product labels developed by industry in accordance with ISO Standard 14025 *(5)*. The scoping document for an EPD, which is also referred to as a product category rule (PCR), defines the requirements for EPDs for a certain product category.

To publish an EPD for a product, an LCA must first be conducted. EPDs can be created using an industry-average LCA developed for the PCR's product or group of products, or it can be more specific to a particular region or a specific plant (*6*). The more localized it is, the better.

ISO Standard 14025 includes a critical review process to ensure that the ISO standards and the industry consensus standards described in the PCR document are followed (*6*). ISO Standard 21930 *(7)* provides more specific rules for environmental product declarations of construction products and services for buildings and civil engineering works. ISO 21930 is in part based on an earlier European Union standard for EPDs for buildings and civil engineering works, EN 15804 (*8*).

Development and use of PCRs help make EPDs comparable. PCRs are especially valuable when an industry-average LCA has been done as part of the PCR development process because it helps to identify and fill gaps in background data (i.e., data for processes upstream in the supply chain from the product of interest) and foreground data (i.e., data for the final process for the product of interest). The PCRs developed for pavement, bridge, and other civil engineering works materials are not more than a decade old, and the researchers, agencies, contractors, and stakeholders in the construction industry are learning about them and finding ways to harmonize methods among the industries in this market sector *(9)*.

EPDs are currently being prepared for number of products in several countries in Europe. Through the implementation of the Buy Clean California Act (BCCA) in 2016, California became the first US state to ask for EPDs (for certain kinds of steel, glass, and mineral wool). The state had already advanced the use of EPDs through a pilot program for pavement and bridge materials (*9,10*) that was conceptualized in late 2015, a year before the use of EPDs was identified as the means for achieving the goals of the BCCA.

In the United States, the scope of most civil works materials EPDs does not cover the complete life cycle. More specifically, their scope includes only the materials extraction and production phases and transportation to the point at which a product leaves the gate of the production plant for the construction site. This scope is sometimes referred to as "cradle-to-gate." It is consistent with the design-bid-build project delivery processes (which are also called "low-bid") typical of most state departments of transportation, where material producers are not responsible for transportation to the construction site, construction, or use of the product.

1.2 Product Category Rule

A PCR document provides guidance to an EPD producer on what to include in an EPD. The contents of a PCR are briefly described as follows:

1. Product category definition and description

   A product category is defined in ISO 14025:2006 *(5)* as list or group of products that offer similar functionality. However, there are several challenges to doing this, such as the definition of the product category, unavailability of local data, limited geographic scope, and the format of the claims about the product's impacts *(11)*. Harmonization among different program operators is a challenge as well due to the conflicting interests of producers within a product category's supply chains and among producers with competing products in different categories.
2. Goal and scope of the LCA-based information for the product category
   i. Functional unit
   ii. System boundaries

iii. Inventory data categories
iv. Data description
v. Criteria for inclusion of input and output
vi. Data quality assessment
vii. Units

3. Life cycle inventory
    i. Data collection methods
    ii. Calculation procedures
    iii. Allocation of materials and energy flows
4. Impact indicators to be reported and calculation rules
5. Period of validity

ISO 14025:2006 *(5)* provides several important guidelines and recommendations to be followed in developing a PCR document. Among these important guidelines are the following:

- LCA studies should be performed as part of the development of a PCR document. This helps make the document complete and consistent. Often, an industry group will perform an initial national industry-average or regional-average LCA that uses typical national or regional values following the PCR. That initial LCA assembled all the information needed for product manufacturers to produce initial EPDs. The initial national or regional EPD provided information that makes it easier for individual companies to produce EPDs for their companies or for plant-specific products by adjusting the formulation (concrete or asphalt mix design, for example) and making other changes needed to make the EPD relevant to their specific product *(6)*.
- PCR documents should be prepared by having all the stakeholders meet to discuss the contents. By doing this, the document produced will address all stakeholder concerns and result in EPDs that will be more consistent and comparable and, therefore, have greater acceptance in the market.
- Program operators should facilitate harmonization when developing a PCR for a product category by considering the adoption of readily available PCR documents in the same product category and in the appropriate market area.
- PCRs are expected to be consistent worldwide. The justification for differing from an existing PCR should be based on the content of existing PCR documents and should not, for example, be based on the origin of any particular PCR. There should be a single PCR per product category, unless there are valid reasons that make that impossible.

1.3 Environmental Product Declarations

As previously mentioned, most EPDs currently include a "cradle-to-gate" LCA—that is, the processes an EPD includes are raw material extraction, transportation of materials to the production facility, and manufacturing/production of materials at the facility. An EPD should also include additional "gate-to-gate" analysis, such as transportation from a cement production plant to a concrete mixing plant and, similarly, transportation of asphalt binder to the production plant for asphalt mixtures. Materials producers follow the PCR document prepared by the industry organization/program operator and reviewed by third-party critical reviewers to see whether it meets international standards and includes appropriate domain-specific considerations. A product EPD is then produced and reviewed by the critical reviewers before it is published. The EPD of a product can be based on facility-specific data or industry-average data. The results of an EPD can then be presented as a product label that looks similar to the "nutrition facts" label seen on a food product (Figure 1.1).

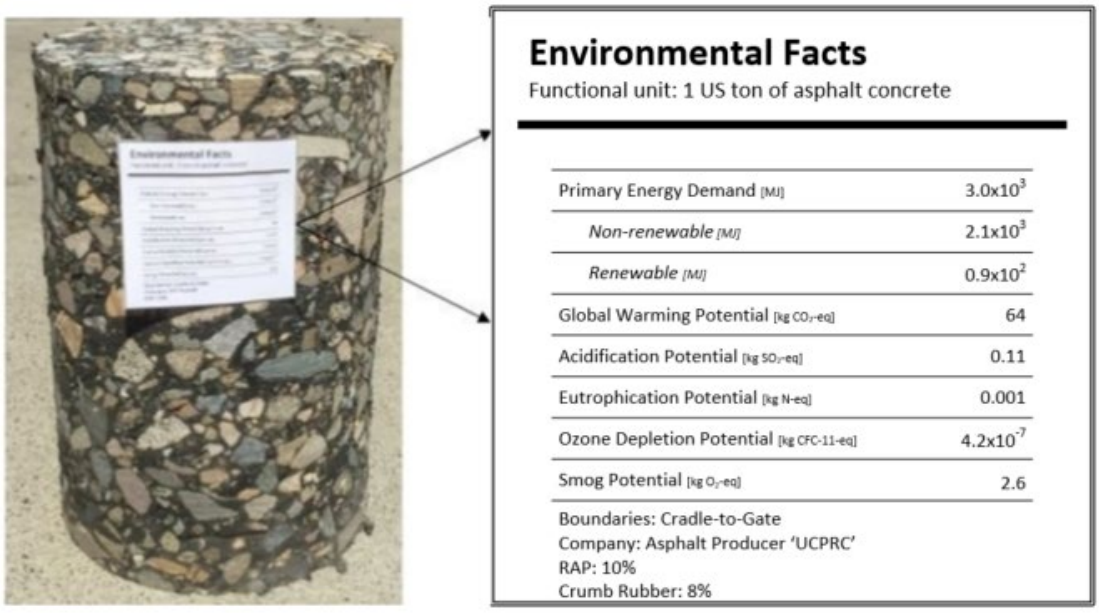

Figure 1.1: An example of an asphalt concrete EPD (prepared by the UCPRC).

The following are some benefits an EPD provides:

- It provides verifiable and transparent information on life cycle environmental impact data for materials or products.
- It allows meaningful comparisons of the environmental performance of materials (if they were developed using the same product category rules).
- It can be used to identify areas for environmental performance improvement, encouraging industry efficiency (*6*).

An EPD can be used for the following purposes:

- Green procurement: An EPD encourages the demand for (and supply of) those products that promote more sustainable use of finite resources and that create less stress on the environment.
- Environmental stewardship: An EPD is a statement that the manufacturer is paying attention to the environmental aspects of sustainability.
- Progress measurement: Periodic updating of EPDs can show the progress being made by a manufacturer or an industry. Agencies can use this information to track supplier progress in meeting agency goals.
- Pavement design: EPDs provide critical information for use in conceptual- and project-level full (i.e., "cradle-to-cradle") LCAs or less rigorous types of environmental assessments of alternative design decisions.
- Pavement management: Industry-average EPD data can be included in the databases used in pavement management systems to perform network-level LCAs (*6*).

1.4 Problem Statement

A full consideration of the environmental impacts from different materials, processes, or projects requires a well-defined, transparent system of communication and reporting. Once that system is in place, environmental goals can be advanced by a department of transportation (DOT) through requiring EPDs from its materials producers. In the United States, EPDs are not currently being used for procurement decisions by any state DOT. However, with increasing awareness and technical knowledge on the part of DOTs and producers, and once higher quality data and improved consistency of calculation and reporting are sufficiently achieved, use of EPDs in the procurement process is expected to be feasible in the near future (*9*). To facilitate this, Caltrans has implemented a pilot project in which contractors supply "cradle-to-gate" EPDs for transportation infrastructure materials. A review of this pilot project is needed to evaluate the level of consistency and reliability of the impacts being reported in the contractors' EPDs so they can be improved where needed.

1.4.1 Goal and Scope of the Project

Caltrans's sustainability goals include reducing greenhouse gas (GHG) emissions by as much as 80% below 1990 levels by 2050 *(12)*. In line with this goal, the approval of Senate Bill 1 on April 28, 2017, requires the implementation of sustainability initiatives, which this project supports. Additionally, the BCCA, also known as Assembly Bill 262 (AB 262), which was signed into law on October 15, 2017, implemented a process of setting maximum acceptable global warming potential values in EPDs for eligible materials that include carbon steel rebar, structural steel, flat glass, and mineral wool board insulation (MWBI). AB 262 requires "specified state departments, the University of California, and the California State University to evaluate greenhouse gas (GHG)

emissions impacts of their projects and incorporate GHG emissions considerations into their procurement processes," and Caltrans is one of those specified state departments. Therefore, bidders for Caltrans projects are required to submit EPDs demonstrating compliance prior to installation on a Caltrans construction project.

Beginning in 2019, Caltrans initiated a pilot study requiring EPDs for hot mix asphalt, aggregates, and concrete, in addition to the materials specified by the BCCA. The requirement to submit EPDs for these materials is how plans made several years prior to passage of the BCCA, for use of EPDs to help achieve environmental goals, are being implemented. While AB 262 considers only GHG emissions contributing to global warming, the Caltrans pilot program for pavement and bridge materials also looks for other emissions in the EPDs, primarily emissions that cause air pollution.

1.4.2 Project Objectives

This study began in the 2014–2017 Partnered Pavement Research Center Strategic Plan Element (PPRC SPE) contract as Project 4.54 (Environmental Life Cycle Assessment Updates and Applications) and continued in the 2017–2020 PPRC contract as Project 3.47 (Support Caltrans with EPDs). The objective of Project 3.47 was to support Caltrans plans and efforts for the implementation of EPDs. This was achieved through the following tasks:

1. Review and help develop Caltrans plans for EPDs.
2. Review PCRs and EPDs for consistency and inconsistencies.
3. Help communicate implementation strategy with industries and the Federal Highway Administration (FHWA).
4. Help build a database in coordination with national efforts.
5. Provide a summary report.

This technical memorandum is the deliverable for Task 5. It presents a summary of the entire project.

2 ENVIRONMENTAL PRODUCT DECLARATION ROADMAPS AND SPECIFICATION SCOPING

2.1 Environmental Product Declaration Roadmaps

Since 2010, most US construction material industry trade organizations have developed and published PCRs and either become program operators or worked with program operators to create EPD programs. Much of this work has been driven by the need for their members to participate in the US Green Building Council's LEED v4 program, which awards points for using materials with EPDs.

Caltrans has two efforts underway with respect to EPDs. The first is responding to AB 262, which includes requiring EPDs, and then using national average baseline values determined by the Department of General Services (DGS) for the four products covered in the law for procurement. AB 262 requires that materials that emit more greenhouse gases than the national average, as determined by the DGS, not be allowed in Caltrans projects. The second effort is continuation of the plan begun prior to AB 262; that is, working toward development of pilot projects and potential implementation of specifications to require EPDs from contractors for most transportation materials, with a focus on pavement and bridge materials. That effort is continuing in parallel with implementation of AB 262.

In early 2018, Caltrans and the University of California Pavement Research Center (UCPRC) developed an EPD roadmap that encompasses a path to implement AB 262 and to utilize pavement and bridge material EPDs in procurement and as input to LCA, as strategies to lower Caltrans's GHG emissions. The roadmap is shown in Figure 2.1. As reported earlier, Caltrans is currently focused on the "cradle-to-gate" part of the pavement life cycle (the green box in Figure 2.1). However, EPDs are not only decision-support documents. They also contain data that can be used as inputs for LCA in "cradle-to-grave" analysis (the orange box in Figure 2.1 includes material, construction and maintenance, use, and end-of-life stages), provided that they meet data quality requirements such as completeness and geographic and temporal applicability.

The overall Caltrans roadmap shown in Figure 2.1 builds off an earlier, more detailed roadmap focused on pavement materials that was developed in early 2017 by the UCPRC with input and oversight from Caltrans. The current version of that roadmap is shown in Figure 2.2.

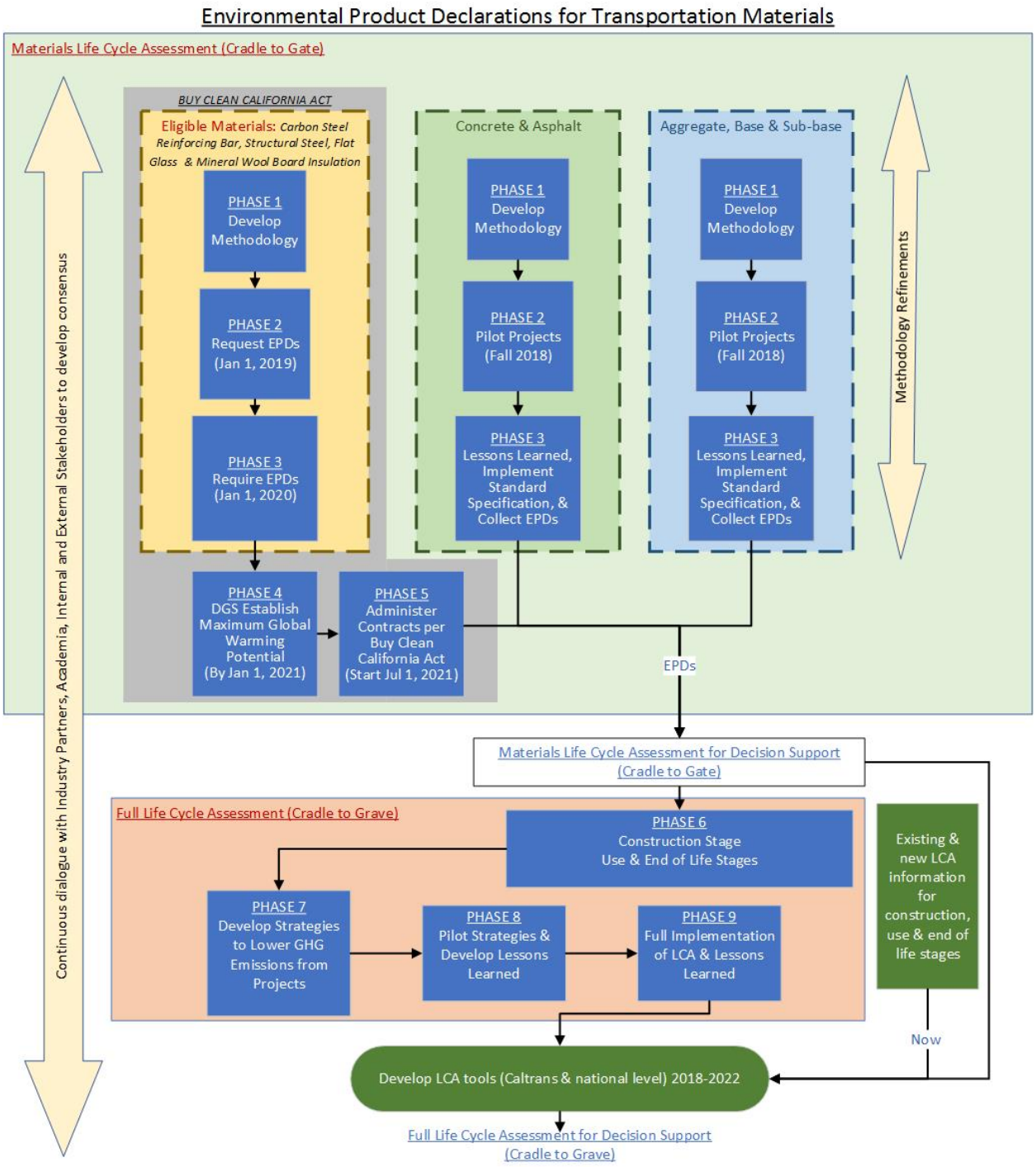

Figure 2.1: Overall Caltrans EPD roadmap for transportation materials.

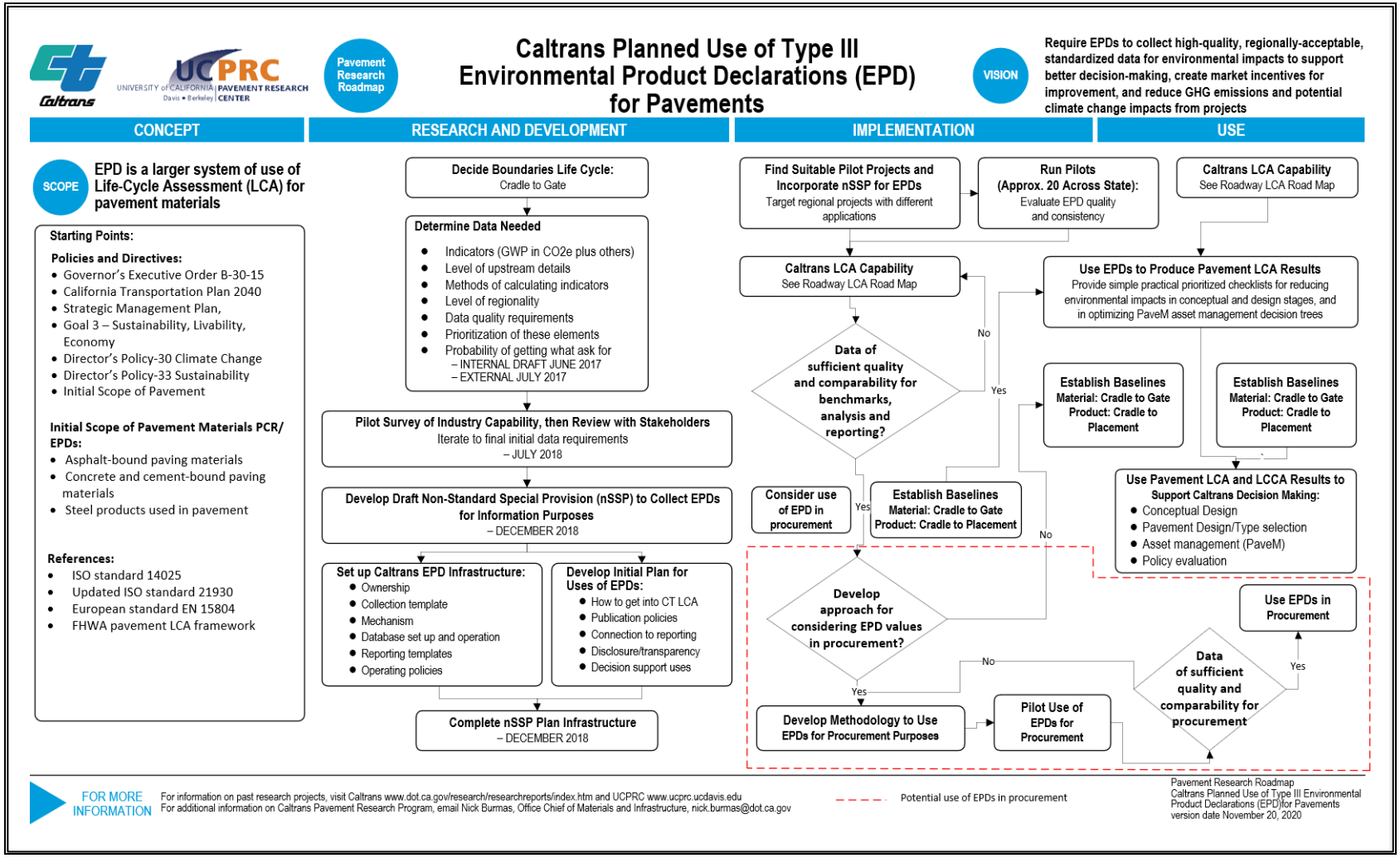

Figure 2.2: Detailed UCPRC/Caltrans EPD roadmap for pavement materials.

2.2 Specification Development Support, Work Plans, and Other Support

In addition to support for the development of roadmaps, and analysis of the EPDs and PCRs in the Caltrans EPD program (presented in the next chapter), the UCPRC has supported the Caltrans EPD effort in the following ways:

- Participation in the development and updating of the EPD task group's work plan
- Support for development of specification details
- Support for outreach
- Support for setting up the EPD intake system and reporting in the Caltrans Data Interchange for Materials Engineering (DIME) web-based materials portal
- Ongoing participation in meetings and discussions

The specification development support primarily focused on help with drafting and review of Topic 6-1.06 of the specifications in 2018 and help with the writing of a white paper titled "Department Exemptions to Environmental Product Declarations in Public Contract Code §3503" that was published by Caltrans in August 2019 (*13*).

The UCPRC also worked continually in the FHWA Sustainable Pavements Task Group (SPTG), including serving as an information contact between Caltrans and the FHWA on various initiatives, developing a technical brief on using EPDs *(6)* that drew on experience working with Caltrans, and organizing discussions about PCRs and EPDs of the SPTG.

3 LESSONS LEARNED FROM PRODUCT CATEGORY RULE AND ENVIRONMENTAL PRODUCT DECLARATION REVIEWS

Caltrans has been requesting EPDs from the producers of seven materials obtained through design-bid-build project delivery for use in state transportation infrastructure projects:

- Included in AB 262:
    - Steel reinforcing bars
    - Structural steel
    - Flat glass
    - Mineral wool board insulation
- Included in Caltrans pilot EPD program and not included in AB 262:
    - Concrete (used in bridges and pavement)
    - Asphalt concrete (used in pavement)
    - Aggregate (aggregate base and subbase used in pavement)

Caltrans's initial focus does not include flat glass and mineral wool board insulation because the department uses those in such small quantities (*10*). Currently, EPDs that are not part of AB 262 are not yet meant for decision support in the procurement process by Caltrans and are being collected for the purpose of data acquisition. The intention is that the EPD data can be used in several ways:

- As feedback to industries regarding PCR and EPD harmonization
- For baselining of GHG emissions
- As support for the setting of GHG thresholds for each material by DGS
- For use in LCAs performed by and for Caltrans

The next two sections of this chapter review and discuss consistencies and inconsistencies in the PCRs and in the EPDs submitted to Caltrans as of the summer of 2020.

3.1 Review of Product Category Rules

The PCRs and program operators for materials in the Caltrans EPD program are summarized in Table 3.1, along with the period of validity for each PCR and the standards they referenced.

A review of consistency across PCRs indicates that there are several areas that could be consistent among the different PCRs but mostly are not.

Table 3.1: PCRs and Program Operators for Materials in Caltrans EPD Program

Materials	PCR Title	Validity Until (month, year)	Program Operator	Standards Used to Develop PCR as Referenced in the Respective PCR
Concrete	Product Category Rule for Environmental Product Declarations PCR for Concrete *(14)*	February 2024	National Science Foundation (NSF) International—National Center for Sustainability Standards	• ISO 14025:2006 • ISO 21930:2017 • EN 15804–2012
Asphalt Mixtures	Product Category Rules (PCR) for Asphalt Mixtures *(15)*	January 2022	National Asphalt Pavement Association (NAPA)	• ISO 14040-14044:2006 • ISO 14025:2006 • EN 15804–2012
Aggregates	Product Category Rule for Preparing an Environmental Product Declaration for Construction Aggregates: Natural Aggregate, Crushed Concrete, and Iron/Steel Furnace Slag *(16)*	December 2021	American Society for Testing and Materials (ASTM) International	• ISO 14040-14044:2006 • ISO 14025:2006 • ISO 21930:2007 • EN 15804–2012
Flat Glass	Product Category Rule for Environmental Product Declarations GANA PCR for Flat Glass: UN CPC 3711 *(17)*	September 2020	NSF International—National Center for Sustainability Standards	• ISO 14040-14044:2006 • ISO 14025:2006 • ISO 21930 • EN 15804–2012
Steel*	North American Product Category Rule for Designated Steel Construction Products *(18)*	May 2020	Scientific Certification Systems (SCS) Global Services	• ISO 14040-14044:2006 • ISO 14025:2006 • ISO 21930:2007 • EN 15804–2012
Insulation Wool (MWBI)	PCR Guidance for Building-related Products and Services in: Brazil, China, Europe, India, Japan, Korea, North America, South East Asia Part A. Life Cycle Assessment Calculation Rules and Report Requirements Part B. Building Envelope Thermal Insulation EPD Requirements *(19)*	February 2023	Underwriters Laboratories (UL) Environment	• ISO 14040-14044:2006 • ISO 14025:2006 • ISO 21930:2017 • EN 15804–2012

* Carbon steel, reinforcing bar, and structural steel are covered under the same PCR document.

Following are the inconsistencies observed in the six PCRs reviewed in terms of the standards used to produce them:

- Some of the PCRs mentioned using a certain standard based on which specific decision was made, while other PCRs referenced standards only without declaring, acknowledging, or informing the reader where that information has been used in developing the PCR. An example is the concrete PCR where several standards were referenced but no specific information was given about which standard was used to develop a given part of the PCR.
- Almost all the PCRs reviewed followed the ISO 14040:2006 and 14044:2006 standards for conducting LCAs, and in the PCR they specifically referenced the standards where they were used.
- With regard to use of the ISO 21930 standard that is specific to EPDs for building and other civil engineering works:
    - The PCR of flat glass, MWBI, and concrete referenced the ISO 21930 standard (different versions were used depending on whether the PCR was developed before or after 2017, when the standard was updated).
    - The asphalt concrete PCR did not mention the ISO 21930.
- Another interesting observation was that some PCRs (MWBI, steel, asphalt) clearly state that the EN 15804 standard was used to develop certain parts of the PCR, while other PCRs (aggregates, flat glass) acknowledged consultation of EN 15804 where and if necessary in the development of the PCR.

The PCRs were reviewed for their reporting of energy use, energy use characterization, and indicator units as shown in Table 3.2.

Table 3.2: Energy Reporting, Characterization Method, and Units Reviewed for the Six PCRs

	Concrete	Asphalt Mixture	Flat Glass	Steel	Aggregates	Insulation Wool
Energy reporting	No mention of LHV or HHV	LHV	No mention of LHV or HHV	LHV	HHV	LHV
Impact indicators required	No mention of what method to use	TRACI 2.1	TRACI 2.1	TRACI 2.1	TRACI 2.1	TRACI 2.1
Indicator units defined	No	Yes	Yes	Yes	Yes	Yes

Notes: Low heating value (LHV), high heating value (HHV); the numerical difference between the LHV and HHV of a fuel is roughly equivalent to the amount of latent heat of vaporization that can be practically recovered in a secondary condenser per unit of fuel burned (*20*).

TRACI: Tool for Reduction and Assessment of Chemicals and Other Environmental Impacts

Low heating value (LHV) and high heating value (HHV) are two different energy values that are obtained from different processes and calculations. It is not simple and straightforward to convert from one to another; in fact, these values are actual measurements from the combustion of a material. The major difference between HHV and LHV of a unit of combusted material is the practical recovery of the latent heat of vaporization in a secondary condenser. HHV is always higher or equal to LHV. Therefore, if one EPD uses HHV to report energy in its life cycle inventories (LCIs) and another EPD for the same material reports energy in LHV, it becomes impossible to compare them with regard to energy use.

Inconsistencies were seen in the PCRs in terms of LHV and HHV energy reporting requirements. Concrete and flat glass PCRs did not mention anything about HHV or LHV. The MWBI, asphalt concrete, and steel PCRs recommended reporting energy in LHV, and the aggregate PCR suggested HHV. Interestingly, a pavement LCA practitioner cannot use an asphalt concrete EPD and an aggregate EPD together to sum energy use for the same project because the two materials are reported in different heating values, which makes it difficult to arrive at final LCA results and conclusions without further assumptions and calculations that introduce additional uncertainty into the final results.

In the current versions of the PCRs reviewed in this study, almost all required calculation of impact indicators using the Tool for Reduction and Assessment of Chemicals and Other Environmental Impacts (TRACI) method (version 2.1). The concrete PCR did not provide guidance on the use of the Centrum voor Milieukunde Leiden (CML) or TRACI characterization method. This is important because the characterization methods are different: the CML method was originally developed from European studies by the University of Leiden (Netherlands), while the TRACI method was developed with data from the United States by the US Environmental Protection Agency. In addition to differences in the calculation of the characterization factors, some of the reporting units in the characterizations differ. An example is eutrophication potential, which is measured in kg N_{-eq} in the TRACI method and in kg PO_{4-eq} in the CML method.

A general observation for the concrete PCR is that it provides a great deal of flexibility in terms of selection of the LCA practice used to produce the EPD. For example, it is flexible with regard to cutoff criteria, selection of characterization method, energy indicators, and reporting units. An advantage to such an approach is that it gives the concrete industry broad latitude to try different parameters using the PCR, which can lead to a deep understanding and knowledge of this field of study. The disadvantage is that this approach makes the EPDs difficult to compare because of the differences in indicators being reported.

Another observation from the six PCRs was the use of different names and units to report the same energy use and environmental midpoint impact indicator. Table 3.3 and Table 3.4 present the language used to define the energy indicators and midpoint indicators, respectively.

Table 3.3: Names and Units of Energy Indicators in the Six PCRs Reviewed

Concrete	Asphalt Mixture	Flat Glass	Steel	Aggregates	Insulation Wool
Nonrenewable primary resources as energy (fuel), in MJ, NRPRE	Use of nonrenewable primary energy sources for energy, in MJ	Primary energy demand from nonrenewable resources (fossil fuels, nuclear), in MJ	Use of nonrenewable primary energy excluding nonrenewable primary energy resources used as raw materials	Nonrenewable fossil, nonrenewable nuclear, in MJ	NRPRE: Nonrenewable primary resources used as an energy carrier, in MJ
Nonrenewable primary resources as material, in MJ, NRPRM	Use of nonrenewable primary energy sources as a material, in MJ	—	Use of nonrenewable primary energy resources used as raw materials	Nonrenewable material resources, in kg	NRPRM: Nonrenewable primary resources with energy content used as material, in MJ
Renewable primary resources as energy (fuel), in MJ, RPRE	Use of renewable primary energy sources as energy, in MJ	Renewable energy (solar, wind, hydro, biomass), in MJ	Use of renewable primary energy excluding renewable primary energy resources used as raw materials	Renewable (solar, wind, hydroelectric, and geothermal), renewable (biomass), in MJ	RPRE: Renewable primary energy used as energy carrier, in MJ
Renewable primary resources as material, in MJ, RPRM	Use of renewable primary energy sources as a material, in MJ	—	Use of renewable primary energy used as raw materials	Renewable material resources, in kg	RPRM: Renewable primary resources with energy content used as material, in MJ

Note: MJ: megajoule

Table 3.4: Names and Units of Environmental Impact Midpoint Indicators in the Six PCRs Reviewed

Concrete	Asphalt Mixture	Flat Glass	Steel	Aggregates	Insulation Wool
Global Warming Potential (GWP 100)	Global Warming Potential (GWP 100), in kg CO_2-eq	Global Warming Potential, in kg CO_2-eq	Global Warming Potential (GWP), in metric ton CO_2-eq	Global Warming Potential, in kg CO_2-eq	Global Warming Potential, in kg CO_2-eq
Ozone Depletion Potential (ODP)	Depletion potential of the stratospheric ozone layer (ODP), in kg CFC-11-eq	Ozone Depletion Potential/Stratospheric Ozone Depletion (ODP), in kg CFC-11-eq	Depletion potential of the stratospheric ozone layer (ODP), in metric ton CFC-11-eq	Ozone Depletion Potential, in kg CFC-11-eq	Ozone Depletion Potential, in kg CFC-11-eq
Eutrophication Potential (EP)	Eutrophication Potential (EP), in kg N-eq	Eutrophication Potential (EP), in kg N-eq	Eutrophication Potential (EP), in metric ton N-eq	Eutrophication Potential, in kg N-eq	Eutrophication Potential, in kg N-eq
Acidification Potential (AP)	Acidification potential of land and water resources (AP), in kg SO_2-eq	Acidification Potential (AP), in kg SO_2-eq	Acidification potential of soil and water (AP), in metric ton SO_2-eq	Acidification Potential, in kg SO_2-eq	Acidification Potential, in kg SO_2-eq
Photochemical Smog Creation Potential (POCP)	Smog formation potential (SFP), in kg O_3-eq	Photochemical Smog Creation Potential/Smog (POCP), in kg O_3-eq	Formation potential of tropospheric ozone (POCP), in metric ton O_3-eq	Smog Creation Potential, in kg O_3-eq	Smog Creation Potential, in kg O_3-eq

Each of the energy indicators has a different name in each of the six material PCRs even though the indicator is the same (i.e., each row in Table 3.3 has the same LCI energy indicator but they are named differently). Furthermore, the aggregate PCR recommends reporting in the units of mass for materials that can be combusted as an energy source but are used as materials, while the other PCRs recommend reporting them in energy units.

Naming indicators differently was also common among all the PCRs when defining TRACI midpoint indicators. Smog formation potential, photochemical smog creation potential, formation potential of tropospheric ozone, and smog creation potential all mean the same thing and are characterized in units of O_3-eq. Four of the PCRs recommend midpoint indicator units of kg for the mass of the reference pollutant, while the aggregate PCR suggests using metric tons and the concrete PCR does not provide guidance on what unit to use.

As awareness and information about PCRs and EPDs grows, industries are adopting better language and decisions about their use. A good example is the MWBI PCR managed by UL Environment, which shows a big difference between its use of language in the 2013 PCR and the 2018 update. In 2013, the PCR recommended using either LHV or HHV to report energy, but the 2018 version clearly requires using LHV.

The last items compared in the material PCRs were their functional and declared units. A declared unit is used when the function and/or the performance characteristics of a construction product are not defined at the building level or when the scope of the LCA is not "cradle-to-grave" *(8)*. As shown in Table 3.5, the different PCRs used different declared units; however, the declared units are aligned with typical purchasing units for their respective products.

Table 3.5: Functional/Declared Unit Comparison of Different PCRs

	Concrete	Asphalt Mixture	Flat Glass	Steel	Aggregates	Insulation Wool
Declared Units	1 US cubic yard or metric tonne (1,000 kg) or 1 cubic meter	1 short ton	1 metric tonne	1 metric tonne or 1 short ton	1 metric tonne	1 m² of insulation material with a thickness that gives an average thermal resistance, RSI = 1 m²K/W

Finally, it should be noted that improvement is currently needed in the transparent reporting of background and foreground data and in ensuring that these data can be used with confidence. Today, there are only a few commercial providers of background data (such as Sphera and PRé), and one US public life cycle inventory database from the National Renewable Energy Laboratory. High-quality complete data are expensive or mainly proprietary and may not be disclosed, and data that are publicly available are usually incomplete. One of the drawbacks of using EPDs as inputs to LCA is that they do not state the background data used in their calculations, and this can introduce additional variability.

3.2 Review of Environmental Product Declarations Received by Summer 2020

By mid-2020, when this analysis for the Caltrans pilot project was completed, approximately 14 EPDs had been collected.

The review of the EPDs showed that many of the individuals filling in the information from an EPD in the Caltrans DIME web portal system were either unfamiliar with the LCA terms in the EPDs or did not have enough information to match the information in the EPD to the data reporting requirements in the DIME system. Upon further investigation, it was found that the indicators named in an EPD often did not match the naming convention

of the PCR under which the EPD had been published. To avoid confusion during reporting, it is highly recommended that the naming convention used in an EPD is the same as that used in the governing PCR.

Other potential problems observed regarding the input of EPD information into the Caltrans DIME system include the following:

- The same EPD declaration number was used by the same supplier, but the indicator values were very different (assumed to be a mistake in reporting).
- The same EPD was submitted for different projects (probably an industry-average EPD was being used).
- Suppliers submitted the same EPDs for different projects and only changed a few indicator values without discernible reasons.
- Identical EPDs were submitted except that they used different naming conventions to define the same indicators.
- Potentially incorrect reporting was indicated by outlier values, with no apparent reason for the seemingly unreasonable values.

The UCPRC is expected to continue its support of the EPD pilot project implementation for Caltrans in the 2020–2023 contract, including updated analyses of PCRs and EPDs.

4 CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations are based on the review of PCRs and EPDs.

4.1 Conclusions

The PCRs for the materials in the Caltrans EPD program have inconsistencies that should be relatively simple to resolve with direction from Caltrans. In their current form, consistent data entry is difficult in the Caltrans EPD portal. For example, even though the same standards (ISO 21930:2017) and midpoint indicators (the TRACI method) were being used, every program operator used different terms to define the same indicator. Although US standard units were generally used, the review of the PCRs revealed differences in the program operators' decisions and recommendations for using a single name and unit system. Currently, this means that entering the data into the Caltrans portal would require making a customized input screen and database structure for every PCR.

To improve the consistency and quality of EPDs, Caltrans staff must receive guidance on how to review EPDs, and staff at materials producers require training about how to interpret PCRs to produce EPDs. Where a program operator does not have a standardized system for producing EPDs from a given PCR, the PCR may be interpreted differently by different companies. Systems for inputting data from EPDs into DOT reporting systems that include data quality checks, system consistency, and certification are also needed. Similarly, a nationally accepted and adopted data quality assessment standard is needed for EPDs as DOTs move toward their use in procurement. All the PCRs examined recommended data quality assessment but did not give detailed instructions. A single data quality matrix should also be included in a harmonized PCR.

The system used to produce EPDs must be transparent. This is key for providing users with confidence in the data the EPDs contain, so that they use the data to support reporting and decision-making. If they do not use the information in the EPDs, then the system will be unsuccessful and the cost of producing them will be wasted. As part of consistency and data quality assessment, it is also important to have a standard metadata reporting system included in the PCRs. While it is acknowledged that industry has proprietary data requirements that it will maintain, all other data sources need to be reported so that the results can be reproduced and EPDs can be more transparent. Mix designs for concrete and asphalt mixtures (nonproprietary elements of job mix formulas, for example) could potentially be included in the EPDs under the design-bid-build system. Transparent verification of performance-related properties in lieu of job mix formulas is a next step in this direction. This will be beneficial in the future for agencies and industry as well as for those using LCA tools for planned projects. These data can also help in early planning level LCA studies as well with decision support.

4.2 Recommendations

The following recommendations are based on the conclusions drawn from the review of PCRs and EPDs:

1. Caltrans should follow and encourage progress in PCR development work being done by program operators, FHWA, and other state DOTs to develop a standardized set of indicator names and reporting units that is harmonized across all PCRs and a standardized set of defined units within PCRs for transportation infrastructure construction materials in the United States. Wherever important necessary differences exist between industries, separate PCR subsections will need to be developed that are specific to a particular construction material. The FHWA is working in this direction, toward a standardized data architecture for pavement LCA data.
2. Following the first recommendation, the Caltrans EPD specification should be reviewed to require consistent names and units for impact indicators and flows across EPDs and declared units within PCR categories.
3. Caltrans should develop processes for reviewing submitted EPD data and rejecting data that are clearly incorrect or incorrectly reported.
4. To facilitate each of the first three recommendations and to better manage the increased use of LCA, the department should consider developing increased in-house LCA expertise through training.

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