Recommended Approach for Use of Cradle-to-Gate Environmental Product Declarations (EPDs) in Procurement of Civil Infrastructure Materials

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A White Paper from the National Center for Sustainable Transportation

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16. Abstract
Procurement of more environmentally sustainable materials for civil infrastructure can be supported using environmental product declarations (EPDs). An EPD is a standardized label that is a scientifically sound way to communicate the potential environmental impacts and selected resource use and waste production flows from all or part of the life cycle of a product. To be called a Type III EPD, the life cycle assessment (LCA) for products used in civil infrastructure must be performed in accordance with ISO standards and the relevant product category rule (PCR) for the product type. Most EPDs for civil infrastructure materials in North America are "cradle-to-gate", i.e., they include the impacts from the extraction of raw materials from the earth and end at the point at which the product is ready to leave the gate of the last manufacturing location. The steps leading to publication of an EPD include: 1) Developing the PCR, 2) Developing the LCA for the EPD, 3) Creating the EPD, and 4) Verification and publishing of the EPD. Industry-average, regional-average, product-specific, and facility-specific EPDs—with differing specificity to a particular product—are used for different purposes. EPDs are a source of data for materials impacts for use in assessment of the complete life cycle. They provide information to identify changes in impacts that can be made early in the materials production. They also can be used to help procure lower impact materials. This white paper discusses benefits of using EPDs and makes recommendations for improving their validity. Several areas needing improvement in current use in procurement are identified and recommendations are presented for improving the use of cradle-to-gate EPDs in transport infrastructure construction materials procurement and to provide input to complete life cycle pavement LCA to support decision-making.

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Improving Life Cycle Sustainability and the Role of Environmental Product Declarations

Procurement of materials is one of the processes in the asset management and project delivery cycle of civil engineering infrastructure. Procurement of more environmentally sustainable materials for civil infrastructure can be supported using environmental product declarations (EPDs). An EPD is a standardized label that resembles the nutrition statement on a food product, presented in a scientifically sound way to communicate the potential environmental impacts and selected resource use and waste production flows from all or part of the life cycle of a product (e.g., midpoint indicators for potential environmental impacts, uses of resources such as renewable and nonrenewable energy resources, and production of waste). To produce an EPD, the life cycle assessment (LCA) methodology following required International Organization for Standardization (ISO) and other standards must be used where the life cycle or truncated life cycle environmental impacts of a material or product are quantified and reported. To be called a Type III EPD, the LCA for products used in civil infrastructure must be performed in accordance with ISO Standard 14025:2006 *(1)* and the more recently published ISO Standard 21930:2017 *(2)*, which was developed specifically for buildings and civil engineering works, as well as the relevant product category rule (PCR) for the product type. Ideally, if a PCR does not exist for a product and before an EPD can be produced, a PCR committee should develop a PCR that meets ISO standards for the product. In cases where a PCR does not exist and there is not enough of a market for the product to support development of a product-specific PCR, the product manufacturer may use the ISO 21930:2017 standard as a core PCR.

Most EPDs for civil infrastructure materials in North America are only for the material production stage of the life cycle of the infrastructure, which is referred to as a “cradle-to-gate” EPD. In cradle-to-gate EPDs, the impacts are calculated starting from the extraction of raw materials from the earth and ending at the point at which the material (product) leaves the gate of the last manufacturing/processing location. Common civil infrastructure materials for which cradle-to-gate EPDs exist are cement, asphalt mixtures, concrete mixtures, steel, lumber, and aggregates. Figure 1 shows where cradle-to-gate EPDs fit in the life cycle of a civil infrastructure project, including raw material supply, transportation of the raw material within the manufacturing supply chain, and product manufacturing. As Figure 1 shows, in ISO terminology, these are sub-stages A1 through A3, referred to as the “product stage.” This white paper focuses on cradle-to-gate EPDs (A1 to A3).

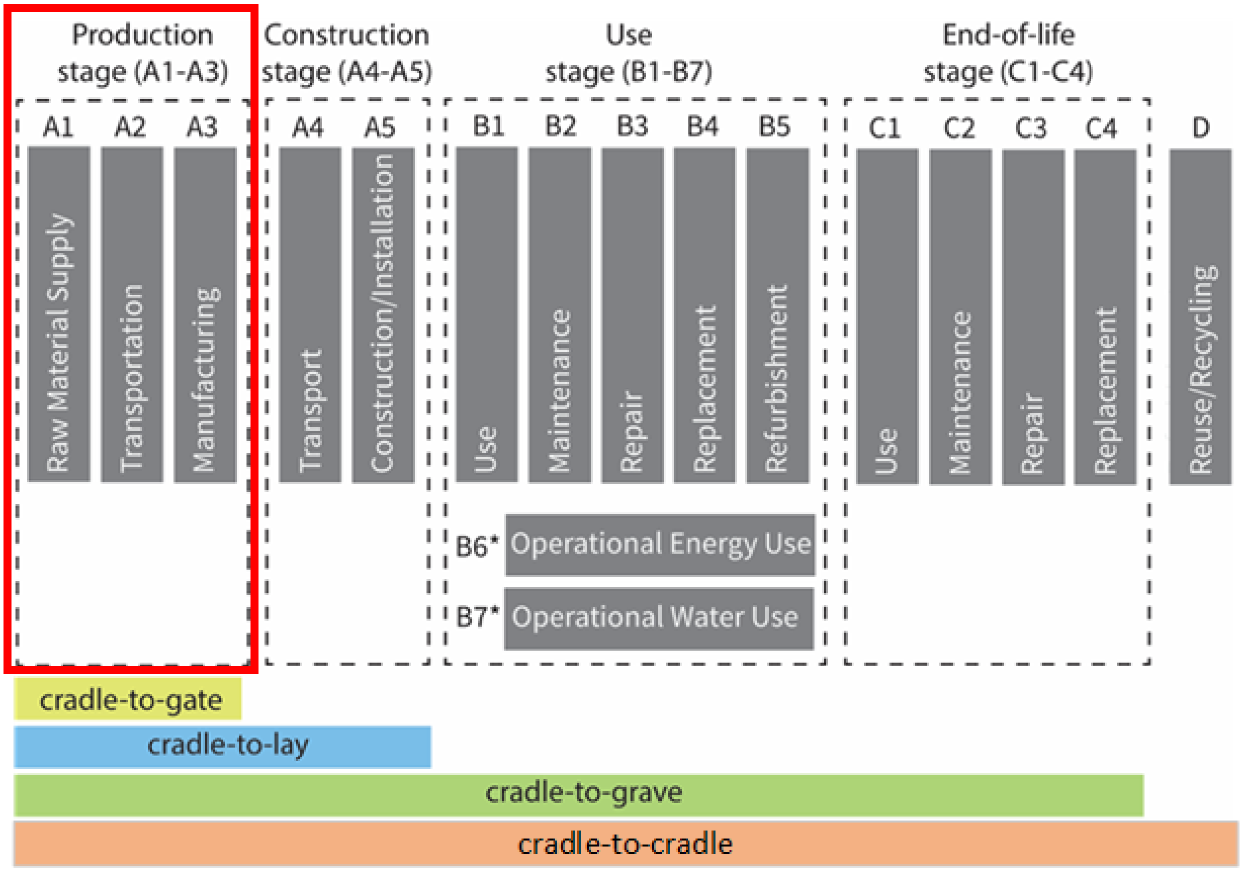

Figure 1. Life cycle stages for building products (adapted from ISO 21930:2017) with boundary conditions for different LCA scopes.

Cradle-to-gate EPDs are appropriate for materials that are used as ingredients in a wide range of final products, such as cement and asphalt binders, aggregate, reinforcing steel, and hydrated lime. For final products, such as pavement materials like asphalt or concrete mixes or even a whole pavement structure, ISO looks for a complete life cycle to be included in the EPD, including the use stage when possible. There are many details to be worked out before complete life cycle EPDs for final pavement materials and structures can be produced because the life cycle of the concrete or asphalt will depend on where and how it is used in pavement, the rest of the pavement structure and its condition, the climate, and the traffic, which are highly variable from project to project. Cradle-to-gate EPDs are a good starting point for all civil infrastructure materials.

The steps leading to publication of an EPD can be summarized as follows (adapted from a Federal Highway Administration EPD Tech Brief *[3]*):

Step 1: Developing the PCR. PCRs define the details of the LCA procedure that underlies the EPDs. PCRs are written by a committee of stakeholders convened by a program operator. The program operator can be a company or a group of companies, an industry sector, or a trade association. In the United States, most program operators are the accredited certification bodies or the national or international industry trade organization for a given product. The roles of program operators range from facilitating collaboration on the PCR committee to hosting PCRs to working with individual material producers to produce EPDs. Many stakeholders are involved at various stages of this process. Participation includes involvement in the PCR committee, submission of comments, and responses to third-party review. A third-party independent review panel, typically with at least three members and including both LCA and subject matter experts, reviews the PCR for logic and compliance with ISO 14025:2006, ISO 21930:2017, and other relevant standards. Typically, the PCR is not final until the independent review team confirms that it meets the relevant standards and is otherwise practical and reasonable. The PCR describes these methodological components relevant to the EPD *(4)*.

An underlying LCA is done for the PCR to identify and deal with issues preparing LCAs for the product type, to identify and prepare data common to all manufacturers, and to set a benchmark "industry-average" LCA based on the data sampled from participating manufacturers. ISO requires an LCA in order to create the PCR. The manufacturers' data used to produce the underlying LCA are proprietary and only shared by the material producers, with the LCA expert preparing the LCA. The industry organization responsible for preparing the underlying LCA will also typically have it independently reviewed. This process can be shortened if relevant LCAs that cover the product category of interest are already published.

Step 2: Developing the LCA for the EPD. To produce an EPD, an LCA is developed based on the PCR for the product or group of products. The manufacturers collect the relevant production parameters (e.g., fuel use, electricity consumption, raw material sources) to be used as LCA inputs. These parameters are known as foreground data. The parameters that the manufacturer does not have control over (e.g., electricity at grid) are typically modeled using LCA databases. These parameters are known as background data. More information on different data types can be found in a companion Federal Highway Administration Tech Brief *(5)*. If the types of foreground data to be collected as well as the background data sources are prescribed in the PCR, the resulting EPDs will have higher comparability and consistency.

Step 3: Creating the EPD. The third step is to use the developed LCA and report its results in the format defined in the PCR. The PCR is also followed for any additional environmental information, the inclusion of materials and substances to be declared, and a period of validity. Currently, EPDs are mainly static documents. However, PCRs and EPDs can be integrated with other software tools, design tools, and databases to enable automation, facilitate implementation, and inform decision-making *(6)*. Using EPDs as dynamic documents can enable the use of EPDs as a data source for LCAs. There is an effort to move to digital EPDs and use of a common OpenEPD digital format *(7)*, which is also being incorporated into ACLCA PCR Guidance *(4)*.

Step 4: Verification and publishing of the EPD. A neutral third party with LCA and EPD expertise or the program operator verifies the compliance of the EPD to the PCR. While ISO 14025:2006 (all EPDs) and ISO 21930:2017 (cradle-to-gate only) have defined specific requirements for the PCR review and EPD verification, ISO itself does not review the credentials of critical reviewers or enforce any standards. The program operator will issue the EPD after the successful completion of the review process, acting as the gatekeeper for the compliance. The name of the verifier and the validity period are specified on the final EPD. These processes are not governed by federal statute or regulation.

PCRs commonly are valid for up to five years. The validity period of the EPD is defined in the PCR. Some PCRs specify that EPDs also have a five-year validity period, which may result in two different EPDs for the same material produced under an expired PCR and under the new PCRs being concurrently valid. Other PCRs resolve this issue by limiting the validity period of EPDs until the expiration of the PCR, also considered in the ACLCA PCR Guidance *(4)*.

The quality of EPDs must be considered by the agency using them in procurement. That quality is highly dependent on the quality of the PCR *(8)*. It is important that the PCR have a high level of prescriptiveness regarding the rules for producing the EPD. A lack of prescriptiveness introduces greater variability and uncertainty in the results due to the use of different approaches and background data. Other factors influencing the quality of the EPD are the qualifications of the experts who produced the EPD and the competence of the outside critical reviewers who check that the EPD follows the PCR. Software tools can be developed by manufacturers or program operators that provide common background data, perform or check calculations, and use a common reporting template. Some program operators have developed software and had it critically reviewed by outside parties to produce all EPDs for their program. The tools can also help reduce the cost of the EPD development.

More information about life cycle thinking and how PCRs and EPDs are produced, their scope, and how they can be used is available from the Federal Highway Administration *(9,10)*.

How Cradle-to-Gate Environmental Product Declarations Are Used

Cradle-to-gate EPDs provide a quantitative statement of the environmental impacts of a material at the end of its manufacturing. EPDs are important, first, as a source of data for materials impacts for use in assessment of the complete life cycle. Second, EPDs provide information to identify changes in impacts that can be made early in the life cycle (materials production). Third, EPDs can be used to help procure lower impact materials.

EPDs are part of an overall strategy for improving the environmental sustainability of civil infrastructure by addressing the impacts of the material production stage in the infrastructure life cycle. The importance of the material production stage to overall life cycle impacts, as measured by EPDs, relative to those in other life cycle stages and the size of the opportunities to reduce overall impacts through changes in material production will depend on the context of the pavement infrastructure. Also, depending on the context, reductions in impacts from changes in material production can be the most important in the life cycle. They can be less than impact reductions that can be made in the design, construction, material transportation, maintenance/rehabilitation management (asset management), use, and end-of-life stages of civil infrastructure *(11)*. The greatest impact reductions will occur when impact reduction strategies are employed in all stages of the life cycle, focusing the most attention on the most impactful stages.

Rewards are also given for EPDs for various civil infrastructure materials in the Leadership in Energy and Environmental Design (LEED) building qualitative assessment process and most other rating systems such as Envision, Greenroads, and Green Globes. Use of EPDs in procurement has been introduced into practice through state legislation in California (Buy Clean California Act, AB 262, 2017) *(12)* and Colorado (2021); by Marin County in California (2019); by the City of Portland in Oregon (2019); and at the federal level (Federal Buy Clean Initiative, 2022). This use of EPDs is being proposed or piloted in other states, counties, and cities. The legislation, regulations, and rating systems have encouraged or required industry to produce EPDs and highlighted their potential uses for agencies.

In the design-bid-build project delivery process, also called low-bid,[1] the sources of the materials to be used on a construction project are not known until the winning bidder (contractor) is selected. The contractor in heavy civil projects (i.e., pavement, concrete bridges, dams, and canals) where design-bid-build is used may or may not be the materials producer. Furthermore, some regions of the country use mobile batch plants for asphalt and/or concrete production on highway projects and the material sources may be unknown until soon before the material is placed. Because design-bid-build contractors are only selected based on cost (sometimes with consideration of construction duration), EPDs are currently typically only submitted to the agency after the project is awarded, when the contractor submits its list of materials suppliers (although general contractors are beginning to consider EPDs earlier in the process). However, the materials suppliers assumed for the bid may not be the actual suppliers used by the contractor during the project. The environmental impacts of materials used by the contractor shown in EPDs delivered after awarding the contract will therefore not typically be part of the contractor selection process.

Industry-average, regional-average, product-specific, and facility-specific EPDs—with differing specificity to a particular product—are used for different purposes, shown in Figure 2. Industry-average or national-average EPDs use average foreground data representative of national trends across a sample of producers. Similarly, regional-average EPDs use LCA foreground data that are typical of a region. In procurement, national-average EPDs can be considered when establishing thresholds or benchmarks for materials that are nationally sourced for civil infrastructure, such as structural steel. Regional-average EPDs can be used to help establish thresholds or benchmarks for materials that are sourced regionally, such as concrete or asphalt mixes. There can be important differences in environmental impacts between regions, such as those from electricity production in different regions, sources and methods of extraction for raw materials, material processing methods, and transportation modes and distances from extraction to processing locations. Some materials are sourced internationally where EPD programs have different PCRs that may use different methods of calculation or the validity of

[1] Project delivery method used on most state and local government highway projects in the United States.

the information in EPDs is difficult to ascertain, which are considerations when materials are sourced from abroad. Some specialty materials can only be sourced from abroad.

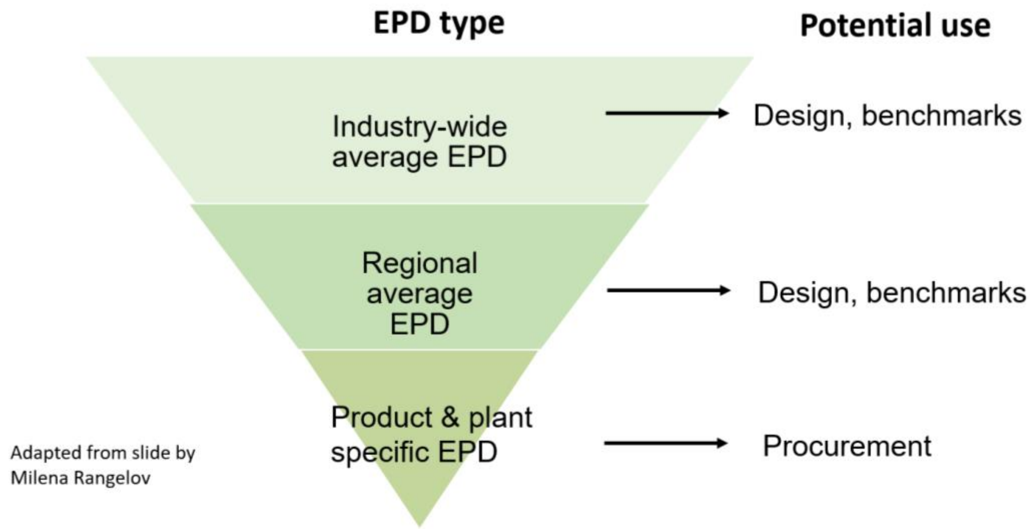

Figure 2. EPD types with different specificity *(8)*.

Different legislation has introduced different terminology. Product-specific EPDs represent the impacts for a specific product and manufacturer across multiple facilities, essentially making them like industry averages but for one producer. The California Department of General Services defines a facility-specific EPD as a product-specific EPD where the environmental impacts can be attributed to a single manufacturer and manufacturing facility. A supply chain-specific EPD as defined in HB 1103 (Buy Clean Buy Fair Washington) 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 *(13)*. The producer should provide product-specific, facility-specific, or supply chain-specific EPDs to the procuring agency for comparison with the threshold or benchmark established by the agency. Agencies using EPDs for this purpose should be specific in their technical specifications regarding what specific type of EPDs they are requesting.

When used in procurement, EPD results may be compared to the agency's specified maximum thresholds for environmental impacts (or one impact if only one is being specified) and only those products with impacts below the thresholds can be used by the contractor on the project, sometimes called a "go/no-go" specification. Alternatively, the impacts can be compared against a benchmark above or below which the material's impacts can be used to apply pay item penalties or rewards, also called "incentive/disincentive."

It is important that the agency identify whether materials being characterized for LCA, compared through cradle-to-gate EPDs for use in design, or evaluated for procurement will have the same performance throughout the rest of the life cycle. This means that the materials being compared should provide the same functionality, in that they should have equivalent functionality over comparable time periods and life cycle stages. Another consideration is that the materials have the same functionality in terms of future end-of-life pathways (i.e., that alternative materials being considered for design or procurement should have a similar ability to be recycled in similar new products or not be recyclable).

Why is this important? Pavement designers should pay attention to functionality and be aware that a material that has a lower cradle-to-gate impact may not last as long, may require more maintenance, or may not be equally recyclable at the end of life as an alternative material and, therefore, might produce more impacts over the life cycle. In other words, EPDs should not be used for comparison of materials whose functionality and performance over the complete life cycle of the specific project design are not expected to be the same. The best way to ensure that a comparison is focused on the same functionality is a comparison over a relevant length of time, say 40 years and over, which could be referred to as a full life comparison. This would cover the performance of the materials in the intended application.

Differences in transportation of materials from the manufacturing site to the construction site are not considered by cradle-to-gate EPDs. Differences in mode of transportation (truck, rail, barge) can be as important, or more important, than transportation distance. Transportation of materials is a consideration for mobile material processing plants, which may be less efficient in processing materials and therefore have greater environmental impacts, but which may have reduced impacts from transportation. This suggests that different criteria should be considered for procurement of materials manufactured at mobile plants and that project-level LCAs considering materials production, transportation, and construction should be used to consider mobile versus fixed plant during design.

Benefits and Caveats of Using Cradle-to-Gate Environmental Product Declarations in Materials Procurement Decision-Making

EPDs provide consumers additional product information to consider in the procurement decision-making process, in addition to cost and the functionality of the material. Public agencies managing civil infrastructure are becoming increasingly aware of the impacts of their activities and opportunities to reduce those impacts. EPDs, while not perfect, help that decision-making process.

Benefits

The benefits of state and local governments requiring EPDs for their construction products include:

- Providing information on potential midpoint indicators for processes or products that conforms with the PCR and applicable standards. Midpoint indicators are considered to be a point in the cause-effect chain (environmental mechanism) of a particular impact category, prior to the endpoint, when characterization factors can be calculated to reflect the relative importance of an emission or extraction in a life cycle inventory *(14)*.
- Allowing meaningful quantitative comparisons of the environmental impacts of materials, provided they were developed using the same PCRs and are for materials that will have the same functionality in the intended application.

- Encouraging industry to become more efficient and less impactful to the environment by recognizing and rewarding innovation, and providing a means for producers to identify areas where they can improve environmental performance. The process of producing EPDs helps companies identify where they can make the biggest improvements in their operations.
- Providing a means to building out open LCA data, once issues of common background data sets and other issues contributing to variability of EPD results are sufficiently addressed through more prescriptiveness in PCRs.
- Most importantly and if properly structured, providing a mechanism for measuring improvement in the environmental impacts of materials through procurement with EPDs.

Caveats

There are several caveats for currently using EPDs for procurement of materials and differing opinions as to the readiness or appropriateness of EPDs for supporting procurement decisions,[2] particularly using the typical current approach for specifying materials or selecting materials using EPDs. The following are some of the caveats.

Thresholds for go/no-go specifications

The basis for setting threshold requirements for purchasing or not purchasing materials in a go/no-go specification needs to be carefully considered. A threshold that is easily and already widely achievable using current practices will not result in improvement. An example to deal with this issue is to add a requirement that over time the thresholds need to be reduced. A threshold that is very difficult to achieve with available technology may result in an inability to get responsive bids. Thresholds could also need revision when functional performance specifications change that can lead to lower or higher thresholds.

Comparability

Use of EPDs in materials procurement requires that the materials are comparable in terms of functionality and that the method of calculating environmental impacts is the same for those comparable materials. Specifically, ISO 14025:2006 requires the following be the same: product category definition, goal and scope of the LCA that produced the EPD, inventory analysis, impact categories, reporting categories, provision of additional information, materials and substances, data collection, format for declaration, equivalency of stages, and period of validity.

Comparability of materials with the same expected functionality (durability and service provided in use in the same application) is largely achieved when evaluating materials for procurement or comparing alternative materials when the EPDs are produced under the same PCR. However, there are criticisms that comparability with respect to these requirements needs

[2] See Pavement LCA 2020 main program (particularly Friday, January 15, 2021) and papers *(15)*.

improvement for EPDs produced under some PCRs. There are also differing opinions as to whether the current state of comparability of EPDs is yet sufficient for a robust, fair procurement process with acceptable risk of perverse outcomes *(16)*. Comparability has improved since most PCRs for civil infrastructure materials now reference the common ISO 21930:2017 (Part A of PCRs) and only call out exceptions and additional information in the PCR (Part B of PCRs). However, variability of EPDs can be high and caused by various factors, particularly choices regarding background data *(17)*. Variability of reporting has also been identified in the California Department of Transportation (Caltrans) EPD program *(18)*. The variability can be decreased by greater detail and prescriptiveness in the PCR—in particular, improvement and greater commonality of use of high-quality background data (basic processes like electricity production and fuel production, including accounting for any regional differences) *(8,19)*. There is recent guidance on development of PCRs and management of quality control by program operators to help overcome variability in the ACLCA PCR Guidance *(4)*. Agencies could require that EPDs adhere to the ACLCA PCR Guidance to encourage greater prescriptiveness in PCRs, and some agencies are considering taking that step.

Comparability of performance requires materials specifications that can identify categories of expected performance in the given application. This comparability is improved when performance-related tests (PRTs) are used with performance-related specifications (PRSs). Materials specifications that are “recipe based” or “volumetric based” provide constraints on how the ingredients of the materials are put together based on experience with similar materials. They do not explicitly assess the expected performance of the material, and therefore are weak in assessing comparability of innovative materials for which durability and service provided (functional performance) have not been established from field experience. As the need for innovation to achieve lower impact materials grows, the use of PRTs and PRSs will need to increase in order to categorize materials for functional performance.

There are gaps in the information needed to produce EPDs that have complete information, particularly for some types of innovative materials. Specifically, environmental impact information from EPDs or published LCAs is currently generally unavailable for many chemical additives often used to produce some types of innovative asphalt, concrete, and other chemically stabilized materials. These materials are typically used in very small doses, but they may be very impactful and contribute to more than 5% of the impact of the material covered by the EPD, thus violating ISO standards for completeness of the EPD.

Agency knowledge

The agency needs to assess the validity and representativeness of the EPD, and there needs to be support for project leaders and others with respect to interpretation of the information in the EPD and assessment of the quality of the information *(20)*. The agency also needs to structure technical specifications for EPDs so that they communicate the requirements for EPDs to suppliers and to facilitate fair and transparent comparisons between products from different suppliers.

Summary of Benefits and Caveats

Interest in the use of EPDs in procurement is growing, and addressing these caveats is moving toward resolution in many ways. There are efforts to improve the standardization of reporting and the ability of procurers to access and compare EPDs *(21)* and to implement PRTs and PRSs in materials specifications at the state level with federal support. Support for local government is a concern as well, particularly in states where technical assistance for local government, even large local agencies, is weak.

The rest of this white paper reviews the typical current approach for using EPDs in the procurement of civil infrastructure materials and offers recommendations for improvements to better achieve the goal of continuous improvement and quantitative feedback on improvement.

Recommendations for Improving the Benefits of Using Environmental Product Declarations in Procurement Decision-Making

Goals for Using Environmental Product Declarations

The goal of using EPDs in procurement decision-making is to make informed product choices, when purchasing construction materials, about the cradle-to-gate environmental impacts of products and materials, within the larger consideration of the life cycle impacts of projects. This goal is achieved by categorizing products and materials in terms of expected performance and evaluating or comparing them based on midpoint environmental indicators. Critical additional goals for the procurement system include the following:

- The procurement system should be practical in terms of ease of use and complexity balanced by the required complexity needed to achieve sufficiently high-quality information and comparability. It should also be cost efficient to maximize the environmental improvement per taxpayer dollar spent by the agency to support decision-making (costs of EPDs are included in the bid prices for projects, explicitly or implicitly). Some considerations for cost-efficiency include the cutoff for the amount of a given material in a project versus the cost of requiring an EPD and the relative overall impacts (impact per unit of material times number of units bought) of different materials in an agency’s portfolio of projects when choosing materials for inclusion in the EPD program.
- The procurement system should be sufficiently robust that the risk of unfair comparisons (e.g., materials are not fully comparable) or unwanted outcomes (e.g., a higher emission material is selected instead of a lower emission material even though the EPD says the opposite) is low. Unfair comparisons and unwanted outcomes can increasingly be avoided as PCRs and EPD program operation are improved, as categorization of materials based on functional performance is improved, as data gaps are filled, and as agencies increase their knowledge and ability to avoid these situations. Progress is rapidly occurring on all these fronts.

- The procurement system should be documented and communicated well so that it is readily accessible and easily understood. Requirements for EPDs need to be included in all contracting documents and guidance, including standard or special provisions, guidance for construction managers, standard pre-bid and pre-construction agendas, and training. Systems for handling general contractor, supplier, and agency staff questions need to be established.
- The procurement system should provide quantitative feedback to both material producers and the agency about whether the EPD-based specification is actually resulting in continuous improvement in environmental impacts.

It should not be assumed that improvements in environmental impacts for materials always result in increased material costs. Decreased environmental impacts can be obtained through different or, in some cases, combined approaches, including changes in mix designs, changes in sourcing of materials, improvements in plant manufacturing processes, changes in energy sources, and changes in transportation distances and/or methods. All of these can be captured by cradle-to-gate EPDs. In some cases, the changes that result in reduced environmental impacts may increase material purchase costs, and, in other cases, they may decrease those costs. The use of EPDs allows material producers to examine everything they do and innovate to find the most cost-effective approaches or combinations of approaches to achieve the environmental goals for which EPDs are a measuring tool. Prescriptive requirements for materials, such as mandating certain types of materials or process changes, may not result in the most environmental improvement for a given producer or might be less cost-effective than another approach to reach the same goal. In the latter case, the agency purchasing the material would be paying more for the same environmental impacts and would be less able to keep the infrastructure functional at the same funding level.

Similarly, improvements in environmental impacts for materials should not be assumed to always require reductions in functional performance, typically defined as how long the material lasts in each civil infrastructure structure and its context for use (e.g., climate, traffic, loads). In some cases, changes in materials that improve environmental impacts are found to improve durability depending on the use and, in other cases, they do not. Comparisons of cradle-to-gate EPDs must consider only materials that have the same expected functionality, including durability for the intended use. Comparisons of materials with different functional performance, including durability, must be done in the structural design process using LCA for entire life cycles (Stages A, B, and C in Figure 1) of the alternatives. Complete life cycle assessment is outside the scope of this white paper; however, it should again not be assumed that reduced environmental impacts will always come at the expense of life cycle cost until the calculations have been done.

Critique of Typical Current Approach and Recommended Changes

The typical approach for using EPDs in civil infrastructure materials procurement that has been implemented up to 2021 has the following elements:

- EPDs are required for targeted materials.
- The agency sets a specified maximum threshold for the environmental impact or impacts of interest.
    - This threshold is typically global warming potential (GWP), although EPDs usually report other environmental impacts such as smog-forming potential emissions, ozone-depleting emissions, fine particulate emissions, and water eutrophication *(10,22)*.
    - The threshold is often set based on a national industry average, if a national-average LCA has been performed (Buy Clean California), or the basis may not be specified in the statute (City of Portland) *(23)*.
    - If there are many categories of functionality for a given type of product, then national or regional averages or other methods must be used to establish thresholds for each product functional group. For example, concrete is currently often categorized based on compressive strength and asphalt mixes by the general type.
- The agency begins requiring that materials meet the threshold soon after requiring that suppliers provide EPDs, often within one year after implementation of the specification.
- Materials above the threshold cannot be used on the project. Materials below the threshold can be used on the project (go/no-go specification).
- The thresholds need to be updated periodically to account for improvements from the pool of suppliers so that there is continuous improvement.

There are several aspects of this approach that limit the effectiveness of the use of EPDs in the procurement of civil infrastructure materials to reduce environmental impacts and that increase the cost and complexity of the process. The following is an assessment of problems with some steps in the current typical approach and recommended improvements.

Use of thresholds/benchmarks scoped to match the pool of an agency's suppliers for each kind of material

The goal is to encourage the agency's entire pool of potential suppliers to reduce their environmental impacts. The use of national-average values to establish thresholds is problematic. National-average LCAs are now required by ISO 21930:2017 to support PCRs. For civil infrastructure materials, which can have tens to hundreds of specifications for materials of the same type across different regions to meet different functionalities, the cost of sampling to update a national threshold can be high and must be repeated periodically or the specification does not lead to continuous improvement.

If the material is sourced regionally because of logistical and cost constraints, such as concrete and asphalt mixes, the national-average impacts may be higher than those of all the suppliers in the region, which means that there is no reduction in environmental impact (a waste of time, effort, and money). This outcome can occur if a region has cleaner electrical energy, shorter supply chains, and cleaner production methods than the national average. On the other hand, logistical constraints, supply chains, or costs may result in none or very few of the suppliers in the region being capable of meeting the national average. The agency then must develop a method to establish a threshold that still provides a large enough pool of suppliers and bidders to avoid a monopoly and encourage the other suppliers to make changes (if they can) to meet the threshold.

Recommended approach to set appropriate thresholds/benchmarks:

- Thresholds or benchmarks should be used that are built on regional data based on the initial collection of published EPDs from the pool of the agency's likely suppliers (scaled to a region in a state, statewide, multistate, national, or international, as applicable) or strong agency-specific data based on prior use of materials. Documentation of the method of calculating thresholds is recommended to increase transparency regarding the data and method used to set thresholds.
- The initial threshold should be established based on EPDs from the agency's suppliers, and the improving EPDs should be used to periodically set new thresholds. This is discussed further in the following fourth recommended approach.
- The setting of thresholds should consider the total quantity of emissions determined from the project-weighted sum of emissions across all EPD-required products in the project, rather than product by product.

Use of incentive/disincentive instead of go/no-go specification

A recommended objective within an EPD program is to improve environmental outcomes, while balancing the desire to encourage as many suppliers to improve as possible. This balancing helps maintain a sufficiently large pool of competitors to help control cost and enough competitors to keep new ideas for innovation entering the marketplace. As defined previously, a go/no-go specification is one where meeting a required limit value for an impact indicator specification, such as GWP, is a binary condition: the specification value is met or not met, regardless of how close or far the reported value is from the specified value.

The use of a go/no-go specification is problematic for two reasons. First, go/no-go specifications do not scale the rewards of the supplier's improvements to the amount of improvement they make. Those who marginally meet the specification have no incentive to do even better. Those whose product does not the specification are not incentivized to do any better than barely meet the specification.

Second, go/no-go specifications can potentially shrink the agency's supply pool and do not make environmental improvement a goal for all suppliers. Those who do not meet the specification, even if only slightly, may choose to not compete for the agency's business. The effects of shrinking the pool on bid costs is unknown and cannot be managed by the agency, and the objective of having a large group of suppliers competing around innovation to improve environmental performance as well as cost can be lost.

Recommended approach for use of incentive/disincentive specification:

- Incentive/disincentive specifications should be used, when possible, to encourage all suppliers except those with the worst environmental performance to continue to improve regardless of where they are with respect to the benchmark. This type of specification is widely used in civil infrastructure construction for materials quality and for construction schedule duration. This approach works by setting a threshold value for emissions and applying a financial penalty for emitting more than the threshold or a bonus for emitting less, scaled to the amount the supplier is above or below the threshold. A second threshold at which disincentives are no longer applied and the material is not acceptable should also established. This approach also allows contractors to quantitatively include consideration of materials supplier improvements in their bid preparation. Federal guidance for material quality allows the use of incentives and disincentives if the quality characteristics of the material can be validated *(24)*. While environmental impacts cannot be directly measured, improvements in PCRs and the operation of EPD programs should provide the required level of validation. Additional federal guidance regarding this topic should be established.
- Use of an incentive/disincentive approach is only easily applicable to civil infrastructure projects where the materials supplier is the general contractor (also called the prime contractor). In larger and more complex projects, construction and materials suppliers often include one or more subcontractors, and materials suppliers may be sub-subcontractors. This presents a challenge from a specification standpoint for the agency, which only pays the prime contractor. Special consideration, and potential language adjustments, will be needed to require that any incentive/disincentive for a specific material be given to, or taken from, the subcontracted materials suppliers or shared between the prime contractor and the materials suppliers.
- Experience with quality and construction duration schedule specifications indicates that bonuses up to 5% and penalties of up to 25% to 50% of the unit cost of the material per unit placed are sufficient to incentivize improvements in industry practices without causing problems to project budgets. A second threshold is set, above which the material cannot be used.
- Thresholds for incentive/disincentive should initially be set near the 50th percentile of the range of emission values established from the collection of EPDs from the agency's pool of suppliers.
- The prime contractor's overall incentive/disincentive should be based on the net sum of the reduction in impacts for the project, rather than material by material. This allows the contractor to optimize the combination of materials they deliver to maximize the reduction for the overall project (and to maximize their incentive). This approach will require consideration and language about how to distribute the incentive/disincentive

to subcontractors. An initial step in this direction would be to set the incentive/disincentive based on the net sum of the reduction in impacts for different types of materials on the project that are most likely to be delivered by a single subcontractor and be included under the same PCR—such as all asphalt materials, all concrete materials, and all steel materials.

Development of product categories that better capture performance and performance-related tests and specifications

A practical balance needs to be achieved balancing the number of categories needed to capture differences in performance-related properties measured using performance-related tests and the complexity of the categorization system. This task can become very complicated for products with multiple performance requirements affecting their overall functionality. For example, concrete for pavement performance is determined by strength, the time to achieve strength, sulfate attack resistance, the coefficient of thermal expansion, and drying shrinkage. For asphalt concrete, performance considers aging, stiffness, fatigue resistance, moisture susceptibility, and rutting resistance.

Recommended approach for development of product categories: Balance the number of functional categories with the complexity of setting up categories and managing them.

Use of the EPD-based procurement implementation schedule to improve the setting and updating of thresholds

The goal of the recommended implementation schedule is to build in time for producers and agencies to develop knowledge and trust in the specification and to make the initial setting of thresholds less costly and more relevant to the agency's pool of suppliers and its geographical distribution. The implementation schedule is also intended to move as rapidly as possible to achieve reductions in environmental impacts while allowing the agency and its suppliers to understand the system and prepare for its implementation. This plan is adapted from the recommendations in the FHWA workshop on the use of EPDs and the challenges *(25)*.

Recommended approach for implementation schedule: Implement the three stages described in Table 1. It should be noted that thresholds may need to go up, rather than down, as missing data for materials, additives, or processes are replaced with new or improved data, resulting in more complete and precise calculation of environmental impacts. This task should be recognized as way to improve data-driven decision-making based on the use of EPDs.

Table 1. Recommended steps and timeline for implementing use of EPDs in procurement of civil infrastructure materials.

Stage	Processes
Stage 1 Reporting and setting of thresholds for cradle-to-gate EPDs (1 to 3 years)	• Develop policies and reporting practices as a move toward standardization of EPDs. • Develop specifications and then require reporting as a move toward standardization of EPDs. • Communicate with contractors and suppliers regarding specification, approach for setting thresholds, requirements for EPD quality, format, and reporting. • Prepare agency procedures for receiving EPDs, reviewing them, and storage of results for setting and later updating thresholds and incentives/disincentives. • Train agency staff to review EPDs for quality, format, reporting. • Reward contractors who provide EPDs for their products by making it a pay item they bid on. • Use pilot projects for requesting EPDs to refine the specification for the EPDS, for training agency staff to review them, and to provide feedback to contractors and suppliers regarding problems with quality, format, and reporting. • After sufficient EPDs have been received for a given type and category of material, review the reported values for the impacts to be specified and determine the threshold value and table of incentives and disincentives. Incentives/disincentives should be sufficiently large to have the contractors compete on the EPD results but should not be so high that other considerations of the overall project quality are lost.
Stage 2 Procurement (> 1 to 3 years)	• Require cradle-to-gate EPDs for materials, with incentives and disincentives, in the procurement process: base incentives and disincentives on the total of emissions (usually global warming potential) summed across all materials in the entire project so that contractors can innovate in their materials selection to maximize emissions reductions while also minimizing their bid costs. • Move towards EPDs for the cradle-to-site (including transportation to the site) and then cradle-to-laid (including transportation and construction) as the ability of industry to quantify and verify these processes improves.
Stage 3 Ongoing improvement in reductions	• Annually summarize and review the emissions from materials procurement. including the normalized emissions (per pay unit of material purchased in a given material type and functional category). Track whether the specification is having the desired effect, and review changes in threshold and/or incentive/ disincentive if not effective. • Update thresholds periodically to result in increasing reductions in impacts. Updating every 2 to 4 years, depending on the financial ability of the agency. will result in continuing reductions and sufficient new data to support updates The incentive/disincentive structure should also be updated at this time. Generally over time, the need for incentives should decrease and disincentives can become steeper without increasing bid costs. Disruptive changes in material types and production technologies should be reviewed to determine whether large changes in thresholds can be made. The costs and capacity of the agency's suppliers to implement those disruptive changes should be considered, and methods to support those changes should be investigated.

Summary

Life cycle thinking is the process of evaluating the effects of project, policy, or operation changes on the sustainability of a defined system across the life cycle of a product. Life cycle thinking can be used at various stages in the life cycle of a product or system to identify opportunities to improve the sustainability performance of products and pavements or to inform and guide decision-makers setting priorities for change. Life cycle thinking works best when quantitative analysis is performed using a set of sustainability metrics identified as important at the start of the process and allows decision-makers to look at improvement options while being informed about potential trade-offs and unintended consequences, either for different aspects of sustainability or between different life cycles.

The use of cradle-to-gate EPDs can be an important part of the implementation of life cycle thinking to improve the sustainability of civil infrastructure. The use of EPDs in procurement of materials for civil infrastructure has been of increasing interest to state and local agencies, and implementation has been driven in part by legislation. However, EPDs need to be specified and managed well to make them an efficient and reliable tool for helping to improve environmental sustainability. This white paper reviews the use of EPDs, provides a summary of several important problems identified with the approach that has been implemented to date, and offers recommendations to improve the practicality of EPDs, reduce their cost, and increase the environmental improvements that they can help produce.

The following are specific recommendations for policy and implementation for use of EPDs as input to LCAs and for procurement.

For procurement:

- Use regionally based—or for large agencies, agency-based—thresholds based on EPDs collected from the pool of suppliers to the agency. Set initial thresholds based on several years of EPDs collected for information only, and periodically update thresholds as technologies improve.
- Consider setting thresholds based on the total quantity of emissions determined from the project-weighted sum of emissions across all EPD-required products in the project or the project-weighted sum of emissions across a given type of EPD-required product, rather than product by product.
- Consider the use of incentives for emissions less than the threshold and disincentives for emissions greater than the threshold, rather than a "go/no-go" specification that does not incentive producers to do more than just meet the threshold and eliminates materials from the competition that do not meet the threshold by a very small amount. Base the contractor's overall incentive/disincentive on the net sum of the reduction in impact for the project, rather than material by material. An initial step in this direction would be to set the incentive/disincentive based on the net sum of the reduction in impact for different types of materials on the project that are most likely to be delivered by a single subcontractor and to be included under the same PCR—such as all asphalt

materials, all concrete materials, and all steel materials. Require the prime contractor to distribute the incentive/disincentive to the subcontractors delivering those materials.

For use in procurement and as input to LCA:

- Balance the number of product categories and material types within each category subject to EPDs and that meet the thresholds with the complexity of setting up categories and managing them. Focus on those with the largest use and largest impacts.
- Encourage use of EPD approaches that reduce the variability of EPD results for a given material, including more prescriptive product category rules, standardized use of regional background data, and requirements for EPDs for critical ingredients such as cement and asphalt binders and additives.[3]
- Develop approaches for EPDs for products that have multiple EPD-regulated materials, such as steel reinforced concrete products.
- Encourage the filling of data gaps with product- and manufacturer-specific EPDs for chemical additives used in asphalt and concrete mixtures (use of proxy data or industry-average data may result in important undercalculations of the environmental impacts for the specific additives used in the material).
- Develop national standards for electronic reporting formats, units, and other presentation of information in EPDs that can be incorporated into PCRs. Complete and implement the development of standards already under way.[4]

[3] See Footnote 4 in ACLCA PRC Guidance *(4)* for additional information.
[4] See the common OpenEPD digital format *(7)*.

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