

White Paper

CDOT Implementation of House Bill (HB) 21-1303 (Buy Clean Colorado Act) for EPD Collection on Key Construction Materials Used in Publicly Funded Transportation Projects

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Colorado HB 21-1303 “Buy Clean Colorado Act” directs the Office of State Architecture and Colorado Department of Transportation (CDOT) to establish policies that reduce greenhouse gas emissions over time by accounting for and limiting the global warming potential (GWP) of key construction materials in state-funded building and transportation projects. The bill passed the state legislature on June 7, 2021, and took effect on July 1, 2022. According to the bill sponsor, State Rep. Tracey Bennett, the goal of the bill is to encourage manufacturers of construction products to reduce their greenhouse gas (GHG) emissions, and ultimately require architects, engineers, and contractors to specify greener construction materials where those materials are practical and economical (Bennett, 2022). The office of the State Architect is responsible for Section 117 of the bill, Colorado Revised Statutes 24-92-117, which covers building construction, and CDOT is responsible for Section 118 of the bill, Colorado Revised Statutes 24-92-118, which covers transportation construction to include roads, highways, and bridges. The eligible construction materials listed under Section 118 of the bill are asphalt and asphalt mixtures, cement and concrete mixtures, and steel (Colorado House of Representatives, 2021). This white paper focuses on the implementation of Section 118, the transportation portion of HB 21-1303, and the paper summarizes the procedures used by CDOT and its advisory team to develop the specification, protocol, and implementation actions for publicly funded transportation projects.

The Buy Clean Colorado Act directs CDOT to begin collecting Environmental Product Declarations (EPDs) from contractors on eligible materials for CDOT projects starting July 1, 2022. For the purpose of HB 21-1303, an EPD shall consist of a Type III Environmental Product Declaration, which is an environmental declaration providing quantified environmental data using predetermined parameters and is third-party verified in accordance with the International Organization for Standardization (ISO) Standard 14025 (ISO, 2006). The rules and requirements for creating an EPD are established in a material’s Product Category Rule (PCR) document. As shown in Fig. 1, the environmental information of an EPD is subdivided into four life cycle stages: production, construction, use, and end-of-life (ISO, 2017).

Life Cycle Stage Information by Module															
Production			Construction			Use						End of Life			
Raw Material Supply	Transportation	Manufacturing	Transport	Construction/Installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational Energy Use	Operational Water Use	De-Construction/Demo	Transportation	Waste Processing	Disposal
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4

Fig. 1. Life cycle stage information by module

The life cycle stages are further divided into modules, based on the phase of production or use of the product. An EPD may cover combinations of modules, i.e., cover different life cycle stages or parts thereof. EPDs covering modules A1 to A3 are referred to as cradle-to-gate. Cradle-to-gate EPDs include the following modules: raw material extraction and supply (A1), transportation to factory or plant (A2), and manufacturing (A3). Since most environmental studies and embodied carbon policies in the transportation infrastructure industry are geared towards cradle-to-gate (Harvey et al., 2016, Rangelov et al., 2021b, Butt and Harvey, 2021), CDOT and the advisory team decided to limit EPD data collection for HB 21-1303 to the cradle-to-gate modules. This is a pragmatic choice but also a limitation as the environmental performance of a material is defined by how well it performs in its application which goes beyond the production itself. Considering a full life cycle prevents trade-offs that may not be apparent when only looking at the production stage. This limitation is not as significant as one might expect looking at Figure 1 as most of the eligible materials that are used in modules A1-A3 are also used in B2, B3, B4, and B5 which cover the use of materials for maintenance, repair, replacement, and refurbishment. The scope of the bill focuses on materials that are placed in pavement and bridges for any type of CDOT project, which includes new construction, but also activities and projects in B2-B5 that meet the material and threshold requirements summarized later in this paper.

Although EPDs typically report a variety of environmental performance metrics (e.g., ozone depletion potential, acidification potential, eutrophication potential, etc.), HB 21-1303 focuses on the collection of global warming potential (GWP) data of construction materials. GWP is the heat absorbed by any greenhouse gas in the atmosphere, as a multiple of the heat that would be absorbed by the same mass of carbon dioxide (CO₂). GWP is expressed in kilogram (kg) of carbon dioxide equivalents (CO₂-eq) over a 100-year time horizon as defined in the latest version of the Tool for Reduction and Assessment of Chemicals and Other Environmental Impacts (TRACI) assessment methodology developed by the Environmental Protection Agency (Bare et al., 2012).

HB 21-1303 sets forth a timeline for implementation of the law. For CDOT projects advertised on or after July 1, 2022, the winning prime contractor(s) are required to submit EPDs for pre-established bid items. Starting on July 1, 2022, CDOT will have two and one-half-years to gather GWP data from collected EPDs. The gathered data will be used to benchmark environmental emissions from construction materials and to develop maximum GWP limits for each eligible material. By January 1, 2025, CDOT must establish a policy with GWP limits on eligible materials. CDOT may create subset limits within the eligible material categories (e.g., different limits for different strength concrete mixtures). By July 1, 2025, the winning prime contractor will be required to submit EPDs for eligible materials and those EPDs must comply with the maximum GWP limits established by the CDOT policy. Starting on January 1, 2027, and every four years thereafter, CDOT will be required review the EPD policy and adjust the policy to reflect industry conditions, as necessary. It should be noted that once established, the EPD policy cannot be adjusted to be less stringent for any material (Colorado House of Representatives, 2021).

The CDOT EPD policy will request that facility-specific data, as opposed to product-specific or industry-wide data, be collected in the development of EPDs. A facility-specific EPD reports the environmental profile of a specific product (e.g., a specific asphalt mixture produced at a specific facility); a product-specific EPD would represent the environmental impacts for a specific product and manufacturer across multiple facilities; and an industry-wide EPD uses weighted input data to produce results that are representative of average emissions for that product across all producers (Rangelov et al., 2021a, Lewis et al., 2021). Single facility EPDs are preferred for the CDOT initial data gathering since they typically have higher resolution and are better suited to derive meaningful regionally applicable

benchmarks. There are important differences in environmental impacts between regions, such as differences from electricity production, sources and methods of extraction for raw materials, material processing methods, and transportation modes and distances from extraction to production locations. The facility-specific data gathered by CDOT will be used to establish the GWP limits or benchmarks for eligible materials in future years.

Development of a protocol

The Buy Clean Colorado Act prescribes asphalt and asphalt mixtures, cement and concrete mixtures, and steel as the eligible materials that require submission of an EPD on CDOT projects. To clarify this requirement to contractors and project engineers, CDOT and the advisory team decided the CDOT EPD protocol should link construction materials that require EPDs to standard CDOT construction bid items. There are 102 bid item categories with a three-digit number and within those categories there are approximately 6,800 items with unique five-digit codes after the three-digit category number (e.g., 403-32601, 412-00615, etc.) in the CDOT Bid Item Code Book. The bid item categories are grouped by common materials, e.g., 403 for asphalt mixtures, 412 for concrete pavement, etc.

To establish the EPD protocol, CDOT and its advisory team performed multiple quantitative analyses on CDOT bid item expenditures over a five-year period from 2017-2021, balancing the need for completeness and the need to reflect current or recent practice. The team obtained bid item data from the publicly available CDOT Engineering Estimates and Market Analysis Project Item Database. The analyses included all bid items where some material is consumed, something is constructed, and/or something is deconstructed, and the analyses excluded all indirect costs (e.g., profit, overhead, contingency, etc.) and services like mobilization, surveying, and traffic control.

After reviewing all the items in the CDOT Bid Item Code Book, the team identified 32 three-digit item categories whose primary construction material encompasses the eligible materials from the bill. As shown in Table 1, this 5-year program-level cost analysis determined the 32 primary bid item categories represent an average annual expenditure of \$331.7M out of total annual average of \$550.3M of all construction bid item categories, excluding services and indirect costs. This program-level analysis indicated the 32 primary bid item categories represent an impactful portion, approximately 72.3%, of the CDOT budget.

Table 1. Program-level analysis of 32 primary bid item categories

	2021	2020	2019	2018	2017	Annual avg. over 5 yrs
All construction bid items excluding services and indirect costs	8404	7290	6991	7240	5468	7078.6
# of 32 primary bid items	3806	3585	3085	3289	2399	3232.8
Total amount of all construction bid items excluding services and indirect costs (M)	\$550.3	\$484.4	\$476.9	\$456.2	\$325.0	\$458.6
Total amount of 32 primary bid items (M)	\$404.3	\$360.0	\$345.3	\$336.2	\$212.6	\$331.7
Percent of 32 primary bid items of all construction bid items excluding services and indirect costs	73.5%	74.3%	72.4%	73.7%	65.4%	72.3%

The team conducted a 95th percentile analysis of the 32 primary bid item categories from 2017-2021 to focus the initial efforts of EPD collection on bid items used frequently in CDOT's program. As shown in Table 2, the team determined the frequency or the number of years (0, 1, 2, 3, 4, or 5 years)

that the 32 primary bid item categories fell within the 95th percentile of the sum of the primary bid item expenditures over the five-year period. The annual cost of the 32 primary bid item categories were sorted by year from highest to lowest and if the bid item was part of the 95th percentile sum, then the primary bid item was given credit for one year.

Table 2. 95% analysis of primary bid item categories from 2017-2021

Primary bid item category	Annual frequency in 95 th percentile	Primary bid item category	Annual frequency in 95 th percentile
206: Structure Backfill	5	518: Expansion Device	0
310: Full Depth Reclamation	0	601: Structural Concrete	5
403: Asphalt Mixtures	5	602: Reinforcing Steel	5
405: Heating/Remixing Treatment	0	603: Culverts/Pipes	5
406: Cold Bituminous Pavement	2	604: Inlets/Manholes	5
409: Cover Coats	3	606: Guardrail	5
411: Asphalt Binder/Emulsion	5	607: Fence	5
412: Concrete Pavement	5	608: Sidewalk & Bikeway	4
501: Steel Sheet Piling	0	609: Curb and Gutter	4
502: Steel Piling	0	610: Median Cover	0
503: Drilled Shaft	5	612: Delineator	0
504: Retaining Wall	5	613: Electrical Conduit	5
507: Slope/Ditch Paving	0	614: Signs	5
509: Structural Steel	1	618: Precast Concrete	4
510: Structural Plate Pipe	0	619: Water Line	1
514: Pedestrian Railing	0	624: Drainage Pipe	1

Based on frequency of appearance in the 95th percentile analysis, current industry EPD readiness considerations, and functional alignment with the bill, the team narrowed down the 32 primary bid item categories to 13 focus bid item categories, namely 206, 310, 403, 412, 503, 504, 601, 602, 604, 606, 608, 609, and 610. On Colorado DOT projects, bid item category 411 Asphalt Binder is normally part of bid item category 403 Asphalt Mixtures. For the limited projects where 403 and 411 are bid separately, the EPD requirement for both bid items would be combined under item 403. Bid items 610 Median Cover and 310-00900 Hydraulic Cement did not reach the top 95 percent in the analysis, but they were included in the 13 focus bid items since they closely align with the bill. Bid items categories 403, 412, 503, 504, 601, 602, 604, 606, 608, and 609 were all included in the 13 focus items since they showed up four or more times in the 95th percentile analysis and also functionally aligned with the bill categories. Bid item categories 603 Culverts/Pipe, 607 Fence, 613 Electrical Conduit, 614 Signs, and 618 Precast Concrete had a frequency of four or more years but were not incorporated in the 13 focus items since local material manufacturers are currently not ready to develop facility-specific EPDs for these items.

The team conducted a project-level expenditure analysis of both the 32 primary bid item categories and the 13 focus bid item categories to verify removal of the 19 item categories was warranted. Ten representative projects from each of the five CDOT regions with a total combined final bid cost of \$181.5M were evaluated. The individual projects were chosen to reflect the range of typical categories and contract delivery methods that CDOT routinely conducts. Three asphalt paving projects, two asphalt widening projects, three concrete paving projects, and two bridge projects were selected. Those projects ranged from small to large budget expenditure and ranged from conventional design-bid-build to CM/GC contracting delivery methods. The analysis calculated the total cost of the 13 focus bid

item categories, the total cost of the original 32 primary bid item categories, and the percent cost of the 32 primary bid item categories captured by the 13 focus bid item categories. As shown in Table 3, a significant portion, 75.7%, of the average total cost of the 32 primary bid item categories are captured by the 13 focus bid item categories; therefore, the project-level analysis also supports removal of the 19 items.

Table 3. Project-level analysis of focus bid item and primary bid item categories

Project No.	Letting date	Total final bid cost	Total cost of 13 focus item categories	Total cost of 32 primary item categories	% cost of 32 primary items captured by 13 focus items
19201	4/23/2020	\$23,753,931	\$9,346,746	\$12,517,030	74.7%
21893	4/25/2019	\$61,648,292	\$29,142,591	\$44,768,916	65.1%
23605	8/4/2021	\$18,285,665	\$6,906,437	\$9,083,530	76.0%
21254	3/30/2017	\$10,400,281	\$6,272,169	\$8,224,394	76.3%
19495	3/3/2016	\$11,809,212	\$6,071,281	\$6,555,202	92.6%
20757	2/9/2017	\$6,945,725	\$4,359,748	\$4,682,024	93.1%
19357	1/14/2016	\$14,988,511	\$7,458,041	\$8,562,618	87.1%
19664	12/13/2018	\$16,600,000	\$9,037,077	\$11,402,312	79.3%
20121	12/2/2021	\$13,278,579	\$9,370,946	\$9,571,260	97.9%
20817	10/13/2016	\$3,781,558	\$853,104	\$1,886,578	45.2%
	Total	\$181,491,752	\$88,818,140	\$117,253,865	75.7%

Project thresholds and implementation

The CDOT EPD Protocol was published as Appendix O to the 2023 CDOT Field Materials Manual (FMM) on July 1, 2022, and it applies to all projects advertised on or after July 1, 2022. The protocol requests facility-specific data be used in the development of EPDs, including material resources from module A1 used to manufacture the eligible materials in module A3. Partly because both concrete and asphalt pavement projects in rural areas of Colorado often employ portable batch plants where the source of aggregates and other materials may be unknown at the time of bidding, the protocol allowed for EPD submission of eligible materials a minimum of two weeks prior to materials placement, or before they are permanently incorporated into the work.

With the aim of not putting excessive burden on small contractors working on small projects, the protocol provided total project cost limit thresholds for EPD submission. To establish the project cost limits, the team analyzed projects in the 5-year window from 2017 to 2021 with total bids over \$1M and total bids over \$3M. With the \$1M and \$3M project thresholds, 98.9% and 92.3% of total program expenditures of the 13 focus bid items, respectively, would be captured. Accordingly, the team decided on a \$3M total project cost threshold for EPD submission requirements where the total cost would be the final engineer's estimate of the bid items, excluding construction engineering, force account items, and indirect costs. The \$3M project limit can be reduced in the future as the program matures and industries gain EPD development and submission experience.

Similarly, to keep relative EPD development costs to a minimum, the protocol defined construction material quantity limit thresholds for small quantity exemptions. The CDOT FMM (CDOT, 2022) has a Sampling and Testing of Small Quantities section within the Frequency Guide Schedule that sets small quantity limits for bid item categories 206, 403, 411, 412, 601, and 609, which the team decided to mirror for EPD submission requirements. These quantity limits are generally associated with

item cost estimates in the \$25k and \$50k range and the team developed similar quantity limits in the \$25k to \$50k cost estimate range for the other focus bid items without small quantity limits in the FMM. The FMM quantity limits for Item 609 were also modified to match the \$25k to \$50k range. The quantity limits for 10 of the bid item categories in the CDOT EPD Protocol are shown below in Table 4.

Table 4. Bid item quantity minimums for EPD submission

Bid item category	Description	Quantity limits	Units
206	Structure Backfill (Flow-fill)	50	CY
310	Hydraulic Cement	150	Ton
403	Asphalt Mixtures (HMA/SMA/WMA)	500	Ton
412	Portland Cement Concrete Pavement (PCCP)	1,000	SY
601	Structural Concrete (All Classes)	50	CY
602	Reinforcing Steel	15,000	LB
608	Concrete Sidewalk & Bikeway	250	SY
608	Bituminous Sidewalk & Bikeway	500	Ton
609	Curb and Gutter	1,000	LF
610	Median Cover Material	4,000	SF

Industry readiness and challenges

The team anticipated a variety of challenges to successful EPD data collection and these challenges were often dependent on the processes used to manufacture the material and were more pronounced for construction materials where a combination of materials is incorporated, e.g., precast concrete with reinforcing steel. Furthermore, most North American EPD collection efforts to date have centered around building construction and LEED certification, and those processes have largely ignored road and bridge construction. The following are some of team's perceived challenges to EPD development by industry and EPD collection by CDOT:

- If there is no standard software tool for the creation of an EPD of a product, then there could be data inconsistencies in the EPDs collected by CDOT for that product. For example, researchers have found differences in GWP levels from two different EPD generation tools when analyzing 27.5 MPa (4000 psi), 34.5 MPa (5000 psi), and 41 MPa (6000 psi) strength concrete using the same mix designs, system boundaries, and processes (AzariJafari et al., 2021).
- NSF International is the program operator for the concrete PCR (NSF International 2019). Currently, there is no guidance on portable plants in the concrete PCR. After consultation with NSF International, the National Ready-Mix Concrete Association, and two consultants who develop EPDs for concrete batch plants, the team developed appropriate language for concrete EPDs produced at portable plants. This language was added to the CDOT EPD protocol and pending review and approval by the PCR committee, will be included in an addendum to the concrete PCR.
- While the concrete PCR expresses a preference for facility-specific cement EPDs, it allows the use of industry-wide averages. Currently, some but not all cement producers have developed facility-specific EPDs for their plants.
- There is no PCR for asphalt binder, asphalt emulsion, and asphalt additives, and there is little to no EPD guidance on the environmental impacts of asphalt binder production. The National Asphalt Pavement Association (NAPA) PCR for asphalt mixtures (National Asphalt Pavement Association 2022) and Emerald Eco-Label EPD Program developed by NAPA will calculate GWP

for 4 generic types of binder, but these GWP values are nationwide averages, not facility specific, as requested by the CDOT EPD Protocol. The team has been assured that the industry is aware of this challenge and is organizing for future EPD guidance and EPDs for asphalt binder, asphalt emulsion and asphalt additives.

- Although there is a PCR for precast concrete, not many precast concrete EPDs have been issued nationally and even fewer for facility-specific precast products used by CDOT. Since precast manufacturers in Colorado generally produce their own concrete internally, obtain reinforcing steel from a variety of sources, and use a variety of reinforcing steel fabricators, these precast manufacturers do not have the experience or in some cases access to the primary data to currently develop accurate facility-specific EPDs. CDOT and its advisory team are in the process of engaging and educating precast manufacturers on upcoming CDOT EPD requirements on precast products and the steps that should be taken to collect facility-specific EPD data.
- For reinforcing steel, EPDs are generally developed by the mills. The PCR for steel construction products defines the “gate” for reinforcing steel to be at the end of point of fabrication, after cutting and bending has occurred (UL Environment, 2020). Current reinforcing steel EPDs typically use industry average values for cutting and bending, and those EPDs often ignore epoxy coating. Also, there is the lack of EPD guidance for steel prestressing strands and steel post-tensioning cables.
- The CDOT EPD Specification does not currently include provisions for project staff to compel compliance of the EPD requirements. If compliance issues arise in the future, methods may need to be established to ensure EPD requirements are met.

Industry outreach and support

CDOT and its advisory team conducted numerous industry outreach initiatives to ensure a transparent and collaborative process in developing the EPD protocol and provided maximum exposure for implementation of the new law. The team conducted one-on-one meetings with local and national asphalt, concrete, and steel trade groups and with the Colorado Contractors Association. The associations were encouraged to share information about the new EPD rules with their members. Industry trade groups were also invited to present at an EPD training workshop for CDOT project engineers in June of 2022 and at a separate workshop in August of 2022 to specifically for industry stakeholders, e.g. materials producers, fabricators, engineers, and contractors.

The team has developed a spreadsheet-based evaluation tool for industry and CDOT personnel to help determine the bid items on a project that will require an EPD. The tool takes the bid item code, quantity, and unit of each bid item on the project, and it calculates the total amount of each eligible material. The total amounts are compared against the CDOT protocol EPD quantity minimum, see Table 4, to determine if an EPD submission is necessary. The tool also provides the total amount of each material in the industry standard declared unit (e.g., cubic meter for concrete, metric ton for asphalt, etc.) for use as the data input into an EPD generation tool.

Next steps/Conclusion

The team anticipates updates and expansion of the July 1, 2022 CDOT EPD protocol in coming years. It is expected that more bid items will be added to the current list of required bid items, and the requirements for facility specific data will become stricter. As industry knowledge and readiness matures, precast elements, steel items other than reinforcement, and materials that are constituents of

mix designs (e.g., asphalt binder, emulsions, additives, admixtures, etc.) will likely be added to the list. The \$3M project threshold may be revised in the future to include projects with a smaller engineer estimate bid item total. Additionally, CDOT's EPD program may be expanded to include local agency administered construction projects in Colorado.

This white paper summarized the procedures used by CDOT and its advisory team to develop the EPD submission protocol for publicly funded road, highway, and bridge construction projects to comply with the Buy Clean Colorado Act. The July 1, 2022 CDOT EPD protocol initiates a two and one-half-year EPD data collection cycle for eligible materials, the first step in the process outlined in the bill. After EPD data collection and analyzing the collected data, CDOT will establish benchmarks for environmental emissions from construction materials and develop maximum GWP limits for each eligible material. These maximum GWP limits will satisfy the primary goal of the bill, to encourage the manufacturers of construction products to reduce greenhouse gas (GHG) emissions in the production of key construction materials.

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