DATA NEEDS FOR PAVEMENT LCA: WHAT AGENCIES NEED TO KNOW

Introduction

State highway agencies and local governments are increasingly interested in developing and administering policies and regulations to reduce the environmental impacts of highway infrastructure. In doing so, it is important to be aware of indirect impacts and unintended consequences of various activities that occur during a pavement system’s life cycle such as maintenance and rehabilitation activities by highway agencies. To evaluate these environmental impacts, a scientific, unbiased, comprehensive, and transparent platform will benefit both agencies and industry.

Life-cycle assessment (LCA) is a proven technique that can be used to analyze and quantify the environmental impacts of a product, system, or process. LCA is a comprehensive approach that examines inputs of materials and energy and outputs of emissions, wastes, and products from raw material production to end-of-life (see figure 1). Environmental impact assessment tools use the total emissions and wastes to quantify the potential environmental impacts for a variety of characterization factors, such as smog formation, ozone depletion, acidification, and eutrophication. LCA, in conjunction with economic analysis techniques such as life-cycle cost analysis (LCCA) and sustainability rating systems, can be used by agencies and industries alike to make better informed decisions.

In practice, pavement LCA is not ordinarily part of regulatory environmental analyses under National Environmental Protection Act (NEPA) and similar state laws. In the context of pavements, those analyses typically focus more on the impacts of pavement construction activities on water and air pollution and vehicle emissions following construction.

LCA typically includes consideration of stages of the pavement life cycle and a broad range of energy, resource use, and environmental impacts, some of which are not typically considered in regulatory environmental analyses. As examples, LCA considers the impacts of raw material acquisition, material processing, interactions of pavement characteristics and vehicles, maintenance and rehabilitation activities over the life of the pavement, and the end-of-life of the pavement, which typical NEPA analyses do not consider.

Figure 1. Generic life cycle of a production system for LCA.
The data needed to perform an LCA serve as the cornerstone for the analysis and depend on several factors. To aid State agencies and industry partners in getting started with LCA, this tech brief addresses the following key data considerations:

- The data required for different types of LCA use cases, including:
  - The identification of data needs based on different types of LCA studies aligned with the goal and scope.
  - The data that agencies may have internally.
  - The data that are needed from other sources.
- Evaluation and documentation of data quality needed to evaluate certainty of LCA results.
- Methods for dealing with data uncertainty when performing an LCA.

This tech brief does not cover the fundamentals of LCA. An introduction to pavement LCA is available in an [FHWA tech brief on pavement LCA](https://www.fhwa.dot.gov).

**Data Needs for Different LCA Scopes**

The data needed to perform an LCA (including the data quality requirements and the available data sources) depend on the type of questions to be answered by the LCA. An LCA can be as simple as an evaluation of one or more environmental impact categories of a single material or may consider a full pavement life cycle with a comprehensive list of environmental impact categories. Typical applications of LCA include:

- Documenting and benchmarking the environmental impacts associated with current practices and materials and identifying key areas for improvement to meet environmental goals.
- Determining the pavement structural designs and materials with the lowest environmental impacts (with similar life-cycle cost) for a given context and life-cycle functional requirements.
- Evaluating the tradeoffs of implementing a policy such as requiring recycled materials or performance-related specifications in all pavement designs.
- Developing an environmental product declaration (EPD) for a specific product (such as an asphalt or concrete mix design).

All life-cycle stages should be included in any comparison unless it can be assumed that they would be similar for the alternatives being considered. The environmental impacts that are selected as the focus of the study determine what type of input data are needed. Key considerations when defining data needs include:

- The phase of the project delivery process in which the LCA is being performed and the key question the LCA is to address.
- The stages and processes of the pavement life cycle that are within the LCA scope.
- The types of data and data quality levels that are needed to answer the question being considered in the LCA with an acceptable confidence level appropriate for that question.

**Data Considerations for Project Delivery Phases**

Most U.S. public highway agencies use a Design-Bid-Build (DBB) process, in which planning and network-level analysis are done by the agency, design is done by either the agency or a consultant acting on behalf of the agency (and in accordance with agency specifications), and the winning low-bid contractor then delivers the materials and builds the project. As-built data are assembled during construction by the agency’s construction engineer and the contractor. The project delivery phases in a DBB delivery system are shown in table 1.
Table 1. Examples of how LCA data can be used within an agency.

<table>
<thead>
<tr>
<th>Project Delivery Phase</th>
<th>LCA Practitioner</th>
<th>Decision Level</th>
<th>Level of Data Detail Available</th>
<th>Data Use*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network programming (Maintenance &amp; Rehabilitation Activities)</td>
<td>Agency Pavement Management group</td>
<td>HQ</td>
<td>Network level data for pavement type, lanes, condition, IRI, traffic, structure if good as-builts available</td>
<td>General guidelines for materials and construction, timing and selection of treatment levels to reduce impacts; Impacts for multi-year work plans; reporting or comparison of alternative work plans</td>
</tr>
<tr>
<td>Planning, environmental review and programming</td>
<td>Agency Planning group</td>
<td>District, reviewed by HQ</td>
<td>Planning alternatives, including new and changed pavement, forecasts of traffic volumes.</td>
<td>Development of guidelines for reducing environmental and resource use impacts of project and regional planning decisions involving pavement based on LCA of typical projects; Consideration in environmental analysis for prioritization of projects, providing full system, life cycle impacts, impact indicators in addition to those required by regulatory processes; Impacts of long-range general land-use and project planning decisions, such as opening local materials sources, providing access for on-site or nearby recycled materials processing</td>
</tr>
<tr>
<td>Design conceptual</td>
<td>Agency</td>
<td>District or HQ</td>
<td>Conceptual dimensions, typical structures; performance specification, typical maintenance and rehabilitation (M&amp;R) schedules</td>
<td>Structure and materials type design decisions; Baseline development for comparisons in later stages; Materials access and staging decisions; Construction work zone decisions</td>
</tr>
<tr>
<td>Design near final</td>
<td>Agency or consultant</td>
<td>District or HQ</td>
<td>Project specific design estimates and assumptions, regional averages for materials data, performance specifications, M&amp;R schedules</td>
<td>Updates of conceptual design calculations with more precise data; Construction specification decisions</td>
</tr>
<tr>
<td>Design final</td>
<td>Agency or consultant</td>
<td>District</td>
<td>Same as design near final, with final adjustments</td>
<td>Updates of near final uses with more precise data</td>
</tr>
<tr>
<td>Procurement</td>
<td>Contractor, Agency, or both; See Example Uses</td>
<td>District or HQ; See Example Uses</td>
<td>Agency defined rules and data quality. Contractor responds with best data available to the agency LCA specifications</td>
<td>Bid selection (agency, district); Review of standard specifications (agency); Preparation of EPDs (contractor, district); EPD review (agency, district); Requirements for plant specific EPDs (agency)</td>
</tr>
<tr>
<td>Construction</td>
<td>Agency or Consultant</td>
<td>District or HQ</td>
<td>Quantities, distances traveled, final materials and sources, work zone practices</td>
<td>Verification of contractor practices “build-as-promised”</td>
</tr>
<tr>
<td>As-built</td>
<td>Agency or Consultant</td>
<td>District or HQ</td>
<td>As-builts, quantities, distances traveled, final materials and sources, plant- specific, material- specific EPDs.</td>
<td>Delivered performance; Collection of EPDs; Lessons learned and potential policy or specification changes</td>
</tr>
<tr>
<td>Policy or specification Evaluation</td>
<td>Agency or Consultant</td>
<td>HQ</td>
<td>Agency averages and other “typical” information, models, experience, summaries of multiple projects</td>
<td>Impacts of changes in specifications, construction quality and construction practices; Calculation of environmental benefit/cost for changes in specifications and policies</td>
</tr>
</tbody>
</table>

* Any comparisons of pavement alternatives, whether alternative structures or materials, must include all life-cycle stages. Life-cycle stages that are assumed to be similar do not need to be included.
The data necessary for an LCA and the associated quality required are often different at each phase in the project delivery process. For example, in the early stages of the delivery process where conceptual decisions are made, the project scope will be less certain. More detail is added as the project moves through the design process. Even though generic data are needed, it is important to note the data should be created from averages of specific data. Similar to the current practices of data tracking and data collection for costs, material performance, and other parameters of interest to an agency, environmental data collection systems can be established within an agency to support LCAs conducted in the early stages of the delivery process.

An improved project scope and more precise information about quantities and materials specifications become available later in the project delivery process as the level of design completeness approaches 100 percent, or when analyzing a built project using as-built data. In the DBB process, the sources and mix designs of the materials to be delivered are not known until the contractor submits its materials information. For these reasons, data are more specific and the calculations more precise for LCAs performed later in the project delivery process. Data quality needs may also be influenced by the type of decisions the LCA is intended to help inform. The goal of the LCA must align with the overall quality and availability of data.

Data Considerations for Pavement Life-Cycle Stages

In performing a pavement LCA, data are needed for all the stages in a pavement life cycle. A simplified pavement life cycle is presented in figure 2 and shows the inputs (commonly materials and energy) for the new construction, pavement maintenance, preservation, and rehabilitation, and end-of-life stages, along with the outputs (commonly emissions and waste). The use stage occurs after the pavement is constructed and after each maintenance, preservation, and rehabilitation cycle. Key data associated with each input and output are summarized at the bottom of figure 2 and categorized by source.

The types of processes considered in pavement LCA are:

- **Raw Material Extraction.** Processes used in the acquisition and production of raw materials used in the pavement structure. Examples include asphalt binder, cement, water, asphalt additive, concrete additive, and aggregate from a single process or multiple processes at a single site.

- **Material Production.** Material that is formed by mixing two or more raw materials together. Examples include asphalt concrete (a mix of asphalt binder and aggregates), and concrete (a mix of water, cement and aggregates). Information regarding the proportions of the different materials used in the final product is needed.

- **Construction Activities/Equipment Use.** Work performed using a device/equipment/machine that requires energy to operate. One or more pieces of equipment can be used for each activity/operation performed over the pavement life cycle. Energy used by equipment is calculated as the product of the equipment power use per unit of production or hours of operation, and the production output or the number of equipment working hours, including any inefficiency if the basis is the production rate. Examples of equipment use include variable power four-stroke engines using liquid fuel such as diesel, gasoline, or natural gas, and electric motors and electric motor-driven equipment.

- **Material Transport.** Use of transportation equipment/machines to transport/move material or equipment from point A to point B. Energy used by transport is calculated as the product of the energy use per distance traveled for a given mass of a material and the distance traveled by the transport vehicle, including any inefficiencies. There may be different energy uses for different materials if the transport vehicles are constrained by volume rather than mass. Examples of transport include hauling aggregates from quarry site to the asphalt/concrete mixing plant and transporting an asphalt roller from a contractor facility to the construction site. Mobilization transport to a site and the distance of mobilization also need to be accounted for.

- **Waste Management.** Recycling, reuse, or disposal of materials at the pavement end-of-life as well as during some rehabilitation activities. Recycling refers to processing or modifying existing materials for the same or another purpose and reuse refers to movement of material to a different location for the same purpose without modification. Both recycling and reuse can be on-site or off-site, which may or may not include stockpiling. Disposal can include incineration, burial, or other means. Examples of waste management include milling of asphalt pavement and recycling it as reclaimed asphalt pavement (RAP) material, demolishing concrete pavement and recycling it as recycled concrete aggregate (RCA), moving a median barrier, or milling and transporting the aggregates milled from a construction site to a landfill.
Figure 2. Activities over the pavement life cycle.
• **Use Stage.** Various pavement characteristics can have a significant impact on the pavement use stage. These characteristics, and their associated impacts, are summarized below:
  
  - Pavement roughness, macrotexture, and structural response all can affect vehicle fuel economy and, as a result, have significant environmental impacts. Additionally, while transporting materials and equipment, traffic congestion can have a significant impact on vehicle fuel use.
  
  - Pavement surface texture, air permeability, and other characteristics affect noise generated from the tire-pavement interaction. This may impact humans both in vehicles and within the acoustical range of the vehicles operating on the pavement. In addition, surface texture and water permeability affect surface friction and hydroplaning, which are important to roadway safety.
  
  - The permeability of the pavement system influences stormwater runoff and flooding. Pavements that are partially or fully permeable can reduce the peak flow rate by holding precipitation within the pavement and slowly releasing it to the environment. This can also affect pollution flow into receiving water bodies and the resultant temperatures of those waters.
  
  - The albedo (reflectance), heat capacity, and thermal conductivity of the pavement all can affect the absorption of energy from the sun and the emission of reflected and thermal energy from the pavement, which potentially can have both negative and positive impacts on energy consumption through building and vehicle cooling/heating systems, air quality, and human health (depending on a number of factors). For some applications, the albedo of the pavement may also have an impact on the energy needed for lighting for nighttime safety and the visibility of pavement markings.

An overview of different types of data that might be needed to perform calculations for each of the pavement life-cycle stages is shown in table 2. The table includes initial identification of the likely owners of the data:

- Pavement agencies, the road owning agencies that use LCA studies.
- Pavement industries, which include national pavement organizations, regional organizations, and individual companies.
- Other national or regional databases maintained by:
  - Governmental organizations, such as Federal agencies, national laboratories, State agencies other than the pavement agency, and local governmental agencies.
  - Universities and non-governmental research institutions.
  - Private organizations that develop and sell LCA data.

Not all data types are needed for every LCA study.

**Data Quality Issues**

Choosing the appropriate data for LCA does not always have to mean “the best possible data” for all variables. Different data choices can be justified depending on the goal of the LCA. Over time, the data environment is expected to become richer and increasingly better data choices will become the state of the practice. To give one example, when an agency digitizes project information, it can also become available for LCA in an accessible format. Project information that are becoming digitized in State transportation agencies that could be useful for data for LCA are change orders, as-builts, mix designs, and construction quality. Three important issues around data quality are: (a) how to determine data quality, (b) how to deal with data gaps, and (c) how to deal with uncertainty.

There are trade-offs to consider within many of these decisions, including important safety issues. Many use stage effects are currently not well quantified and thus significant uncertainty exists, particularly when considered over long analysis periods (50 years or more).
Table 2. Examples of data needed for different stages of the pavement life cycle and their likely sources (pavement agency, pavement industry, other national or regional databases maintained by governmental and private organizations).

<table>
<thead>
<tr>
<th>Pavement Life-Cycle Stage</th>
<th>Processes/Activities</th>
<th>National/State/Regional Background Datasets</th>
<th>Likely Sources of Data</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Agency Data</td>
<td>Industry Data</td>
</tr>
<tr>
<td>Common to all</td>
<td>Transportation</td>
<td>Emissions, wastes, and material use</td>
<td>Fuel type, transportation type, distances</td>
</tr>
<tr>
<td></td>
<td></td>
<td>N/A</td>
<td>Type, Quantity per process/material</td>
</tr>
<tr>
<td></td>
<td>Electricity</td>
<td>Emissions, wastes, and material use</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Energy</td>
<td>Emissions, wastes, and material use</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Materials (raw material extraction and production)</td>
<td>Emissions, wastes, and material use</td>
<td>Quantities</td>
</tr>
<tr>
<td></td>
<td>Construction Equipment</td>
<td>Emissions, wastes, and material use</td>
<td>Type equipment (power, emissions standards, fuel type), hours needed</td>
</tr>
<tr>
<td></td>
<td>Waste treatment</td>
<td>Emissions, wastes, and material use</td>
<td>Typical waste treatment options, split between different options, distance</td>
</tr>
<tr>
<td>New Construction and Reconstruction</td>
<td>Construction</td>
<td>N/A</td>
<td>Material specifications, Design, &amp; Quantities</td>
</tr>
<tr>
<td></td>
<td></td>
<td>N/A</td>
<td>Expected performance life</td>
</tr>
<tr>
<td></td>
<td></td>
<td>N/A</td>
<td>Construction Activities - equipment type and use, range of typical to project-specific construction equipment type and use practices, construction work zone practices and productivity</td>
</tr>
<tr>
<td>Use</td>
<td>Thermal effects</td>
<td>Thermal properties (albedo, heat conductivity, heat, climate data capacity) of materials; climate data</td>
<td>Initial thermal properties (albedo, heat conductivity, heat capacity) for treatment at start of each stage; albedo change with time for surface.</td>
</tr>
<tr>
<td></td>
<td>Pavement vehicle interaction</td>
<td>N/A</td>
<td>Initial constructed values and performance models for IRI, texture, for treatment at start of each use stage. Traffic counts and class.</td>
</tr>
</tbody>
</table>
Table 2. Examples of data needed for different stages of the pavement life cycle and their likely sources (pavement agency, pavement industry, other national or regional databases maintained by governmental and private organizations) (continued).

<table>
<thead>
<tr>
<th>Pavement Life-Cycle Stage</th>
<th>Processes/Activities</th>
<th>National/State/Regional Background Datasets</th>
<th>Likely Sources of Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preservation</td>
<td>Preservation</td>
<td>N/A</td>
<td>Type and timing of treatments, material quantities for treatments. Construction Activities - equipment type and use, range of typical to project-specific construction equipment type and use practices, construction work zone practices and productivity.</td>
</tr>
<tr>
<td>Maintenance/Rehab</td>
<td>Maintenance/Rehab</td>
<td>N/A</td>
<td>Type and timing of treatments, material quantities for treatments. Construction Activities - equipment type and use, range of typical to project-specific construction equipment type and use practices, construction work zone practices and productivity.</td>
</tr>
<tr>
<td>End-of-Life</td>
<td>End-of-Life</td>
<td>N/A</td>
<td>EOL options Reclaimed material options. Construction Activities - equipment type and use, range of typical to project-specific construction equipment type and use practices, construction work zone practices and productivity.</td>
</tr>
</tbody>
</table>

**Defining Data Quality**

When determining data quality requirements, it is important to relate data quality needs to the goal of the study, the indicators to be used, the sensitivity of the results, and their importance in achieving the goal (FHWA Pavement LCA Framework). Consequently, data quality in LCA can be defined using qualifiers that relate to characteristics such as technology, time, and geography. All data used in the LCA should carry a data quality indicator for each of the characteristics in the list, whether it is a simple high/low/medium rating, a numeric value, or some other kind of scale. Data should also be identified as being primary or secondary, and the sources of secondary data should be identified in the data quality assessment. These should be indicated in the meta-data of any database structures that are established. The FHWA is currently working to develop a comprehensive data mapping of unit processes for pavement LCAs that will include recommended meta-data and data quality indicators.

Best practice for LCA involves the use of best possible data for the processes controlled by the organization performing the LCA. This means that the entity should use its own data for the processes it controls. For example, a supplier providing an EPD should be using its own data for the processes it controls, whereas external data from LCA studies might be used for the upstream processes (in this example, there should not be downstream processes after production for a cradle-to-gate EPD.) Literature data are often obtained from existing commercially or publicly available databases; examples include industry average inventory data for generic products and services, such as material resources, energy, transport, equipment fuel consumption, and waste processes, or scenarios for the use stage and end-of-life.

Figure 3 shows a system diagram for a full-depth reclamation (FDR) treatment with cement stabilization and an asphalt hot mix overlay. For the FDR contractor, primary data are collected for the construction
processes, and secondary data are used for the hot-mix asphalt and the cement production to the gates of those respective production plants. For the asphalt hot-mix producer, primary data are produced for the mixing plant and the aggregate production process (if produced by the hot mix plant), while secondary data are used for the asphalt binder. All producers would be using secondary data for energy inputs.

Figure 4 shows the same system, but this time where the asphalt hot-mix producer is using an EPD for the asphalt binder, and the FDR contractor is using an EPD for the cement binder. Similarly, an EPD could be used for the aggregate production by the hot-mix asphalt producer, if one were available. If EPD data are expected to be used in the LCA process, all EPDs used should be consistent in terms of underlying LCA methodology as well as background data.

According to ISO 14044, data quality is defined as "characteristics of data that relate to their ability to satisfy stated requirements." The data quality requirements are therefore dependent on the goal of the study.
Data quality requirements should specifically address the following items (based on ISO 14044), although the extent to which each of these considerations needs to be documented can be related to their importance to the goal of the study:

- Time-related coverage: age of data and the minimum length of time over which data should be collected.
- Geographical coverage: geographical area from which data for unit processes should be collected to satisfy the goal of the study.
- Technology coverage: specific technology or technology mix.
- Precision: measure of the variability of the data values for each data expressed (e.g., variance).
- Completeness: percentage of flow that is measured or estimated.
- Representativeness: qualitative assessment of the degree to which the data set reflects the true population of data.
- Population of interest (i.e., geographical coverage, time period, and technology coverage).
- Consistency: qualitative assessment of whether the study methodology is applied uniformly to the various components of the analysis.
Handling Data Gaps

The FHWA Pavement LCA Framework states that:

…the initial data quality requirements can be addressed through preliminary sensitivity analysis during the scoping of the LCA. The preliminary sensitivity analysis should consist of evaluation of the indicators and the different possible inventory sources and the sensitivity of the indicators to the uncertainty of the inventory sources for the different processes to be included in the system boundaries. If the sensitivity analysis indicates inadequate primary data, then secondary is often sought as a replacement. Similarly, if the preliminary sensitivity analysis indicates that there is little sensitivity of indicators to the quality of certain data elements then the level of data quality for those elements can be lower.

The same applies to missing data. Missing data should be explained, shown as a “missing value,” or shown with a “modeled value (sometimes referred to as a ‘proxy’) with documentation of the modeling in the goal and scope documentation.” It is good LCA practice to not leave gaps but defining a good proxy can be challenging because of the difficulty in identifying the quality of the proxy data. LCA practice advises to use a “conservative case” (i.e., err on the side of caution) when defining a proxy. This requires a good understanding of the manufacturing process of the missing data. When the LCA is run with a conservative proxy and the proxy turns out to not have a significant influence on the results or conclusions, this is typically considered acceptable practice. But when the choice for a proxy turns out to be relevant to the results, it puts emphasis on the need for getting better data to fill the gap and reducing the uncertainty in the calculations.

Handling Data Uncertainty

Another data aspect is the use of assumptions or scenarios for future based activities. Pavement LCA typically features scenarios for pavement management after construction. The most important information dominating the results of the study is often the expected future maintenance and rehabilitation schedule and the expected end-of-life and end-of-life action. Predictions of future pavement condition (roughness, structural response, and texture) are important for any consideration of the use stage. Data of these types should usually be available to the agency LCA practitioner from the pavement management system (PMS). Any issues with modeling or predicting pavement performance are inherently “copied” into the LCA analysis. In these situations, the practitioner will work with generally accepted models and approaches and ensure appropriate sensitivity analyses are performed to interpret results.

LCA practitioners, just as with LCCA approaches, will assume “similar” performance among comparable design alternatives and build up the LCA model accordingly.

This brings up the topic of uncertainty, which is typically not well defined in LCA datasets. There are pragmatic ways of dealing with uncertainty, for example by performing targeted sensitivity analysis or, where enough data are available, conducting a probabilistic analysis using techniques such as Monte Carlo simulation.

As called for in the FHWA Pavement LCA Framework, the allowable levels of error in the LCA study depend on how the errors influence the conclusions. It is good practice to review the influence of the error on the outcome of the study. If the known error does not change the conclusions of the study, it can be considered allowable. If the known error does change the conclusions of the study, it would be advisable to try to get better data to reduce the level of error. This consideration should help guide the data collection requirements and the subsequent interpretation of the LCA results based on use of those data. The allowable levels of error—that is, the confidence level that the LCA will provide a result that is not correct—should be called out in the goal and scope document. The risks of data used in the LCA study not providing a sufficiently low probability of error which may lead to an incorrect decision must be documented, at least qualitatively, and if possible, quantitatively through the collection of data for sensitivity analysis. If data are not available to calculate the risk of a wrong answer, then a decision
should be made to use or not use LCA as part of the decision-making process.

A long-term objective of the development of LCA for pavement is to be able to use probabilistic analysis where it is needed. At this time, information regarding the statistical distributions of flows and impacts is generally not available and therefore true probabilistic analysis cannot be done.

**What About EPDs?**

**EPDs Defined**

An Environmental Product Declaration (EPD) indicates the environmental impact (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 provide verifiable and transparent information on life-cycle environmental impact data for materials or products using standards defined in a Product Category Rules (PCR) document. This means EPDs are potentially the best sources of data for agencies when materials are modeled for pavement LCA. The primary business incentive for industry to produce EPDs at this time is to gain points in rating systems such as in the LEED v4 framework, but highway agencies could also encourage their development by providing incentives. EPDs are not required by Federal statute or regulation.

**PCR Harmonization Issues**

EPDs from different program operators may not follow the same rules in their respective PCRs, leading to different EPDs. There is no such thing as a national PCR for building materials and there is no generally accepted and well-defined PCR harmonization process in place. This leaves EPDs vulnerable to incomparability and care should be taken to ensure that this does not bias the analyses and the interpretation of LCA results. At this time, differences in PCRs make it difficult to compare EPDs of materials. PCRs are not required by Federal statute or regulation.

More information on this topic is available in the FHWA Tech Brief, *Environmental Product Declarations—Communicating Environmental Impact for Transportation Products.*

**FHWA LCA Tool and Data**

FHWA is developing an LCA tool for use by highway agencies. The goal is to use the best publicly available data for data from upstream processes, suppliers, and agencies. One of the sources for the database is the Federal LCA Commons. The Federal LCA Commons is an interagency community of practice LCA research methods. This community of practice collaborates to share expertise and methods to move toward common Federal data modeling conventions and make Federal data sets freely available through a web-based data repository. The tool will make use of a selection of background data being identified by the Federal LCA Commons for common processes such as transportation, energy and waste treatment. Industry data, such as EPDs, can be included. The user interface will allow agencies to add their own data. It is anticipated that the work focused on data quality for the tool will help lead to increased harmonization.

**Where Can I Learn More?**

Some key resources that provide information on the various tools, techniques, and methodologies related to LCT are provided below. Additional information and resources can also be found on the sustainable pavements webpage.

- [FHWA Sustainable Pavements Reference Document (FHWA-HIF-15-002)].
- [FHWA Tech Brief on Pavement Life Cycle Assessment (FHWA-HIF-15-001)].
- [FHWA Tech Brief on Pavement Sustainability (FHWA-HIF-14-012)].
- [FHWA Pavement Life-Cycle Assessment Framework (FHWA-HIF-16-014)].
- [FHWA Tech Brief on Environmental Product Declarations—Communicating Environmental Impacts for Transportation Products].
- [FHWA Pavement LCA Tool (available 2020)].
- [FHWA Background Data Mapping and Roadmap project including PCR guidance (available 2020)].
- [Federal LCA Commons].
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Distribution: This Tech Brief is being distributed according to a standard distribution. Direct distribution is being made to the Divisions and Resource Center.

Availability: This Tech Brief may be found at https://www.fhwa.dot.gov/pavement/

Key Words: sustainability, pavements, life-cycle assessment, environmental product declarations

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