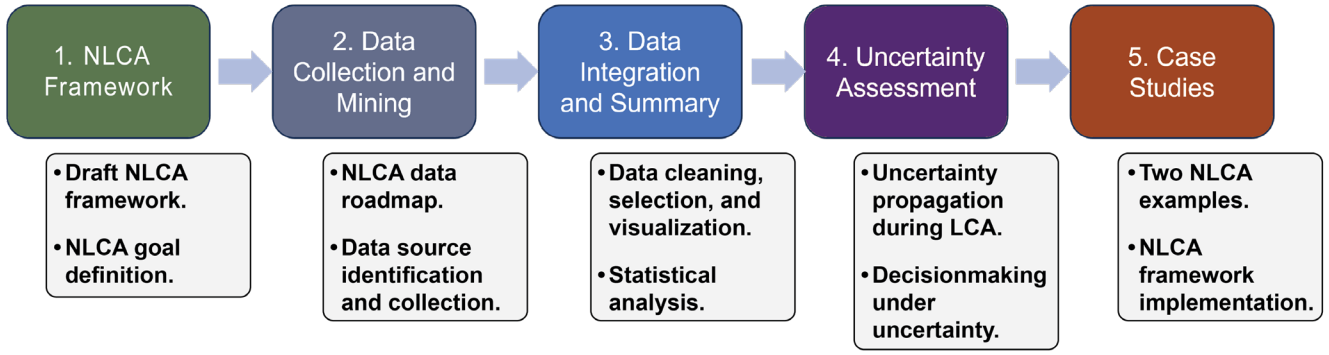
EXPLORATORY ADVANCED RESEARCH

MEASURING DECARBONIZATION IN THE PAVEMENT LIFECYCLE

July 2024

FACT SHEET

As part of their commitment to protecting the environment and addressing climate change, State departments of transportation (DOTs) have acknowledged the importance of factoring in the reduction of embodied emissions associated with construction materials.(1) Given that construction materials constitute a significant expenditure for these agencies, they recognize their direct influence over decisions in this realm. Pavement management can be a suitable phase for considering and introducing environmental improvements to optimize pavement preservation and maintenance treatment timing, location, and type (when, where, and what) because of the phase's focus on system-level resource optimization.



LCA = lifecycle assessment; NLCA = network-level LCA.

An infographic illustrating the five-step network-level lifecycle assessment (NLCA) process.

Lifecycle planning and lifecycle cost analysis are already integral parts of this process. Lifecycle assessment (LCA), a similar analysis focused on environmental impacts, can also be considered. To accomplish this goal, it is essential to investigate the details of pavement management methodological protocols and examine potential strategies for integrating LCA for tracking and quantifying environmental emissions, such as carbon, as part of the pavement process.

The University of Massachusetts Amherst, in collaboration with an engineering firm, is leading a project titled Stochastic NLCA for Flexible Pavement Preservation and Maintenance Schedules. The project leverages existing technical developments concerning pavement materials and pavement-vehicle interaction to develop metrics for supporting NLCA decisionmaking. Specifically, this project focuses on flexible pavements and the maintenance and pavement treatments related to them. Ultimately, this project will bring network-level pavement LCA closer to real-world application. The Federal Highway Administration's (FHWA) Exploratory Advanced Research (EAR) Program provided funding for this project.

METHODOLOGY

The research team's proposed approach will closely follow the FHWA Sustainable Pavements Program (SPP) hierarchy of LCA needs. This approach starts from the LCA framework; data definitions in the decisionmaking context; and data development, collection, and organization. Then the stochastic (i.e., involving a random variable) NLCA modeling framework for flexible pavement systems is developed.(2) While significant advances have been made over the years regarding project-level LCA, a gap for how to conduct NLCA still exists. The method will follow the existing project-level LCA studies and integrate state-of-the-art methodology into a framework geared toward simple and convenient implementation.

U.S. Department of Transportation
Federal Highway Administration

MEASURING DECARBONIZATION IN THE PAVEMENT LIFECYCLE

July 2024

FACT SHEET

The approach will use the following step-by-step process:

1. Develop a framework for LCA methodology for network-level applications.
2. Assemble, develop, and assess data and models.
3. Quantify the uncertainty propagation (i.e., the process of quantifying how uncertainties in input variables affect uncertainties in output variables within a model or system) of existing data variability and model errors into NLCA.
4. Demonstrate application through two case studies.

The research team's analysis will consider both the embodied emissions from flexible pavement treatment applications and the operational emissions that come from the consumption of excess fuel due to pavement-vehicle interaction to inform network-level pavement preservation and maintenance. Ultimately, this research project will give the transportation community a framework for network-level tracking and quantifying carbon emissions as part of the pavement management process.

RESULTS

The research team anticipates the project will provide FHWA with the following:

- NLCA framework.
- Data roadmap.
- Methods to integrate bottom-up, project-level data into metrics for informing network-level decisionmaking.
- Documented methods for integrating uncertainty and enabling stochastic analysis.
- Two case studies.

The project's outcomes could assist State DOTs' efforts to reduce greenhouse gas emissions from highway construction and maintenance operations.

Recommended citation: Federal Highway Administration, *Measuring Decarbonization in the Pavement Lifecycle* (Washington, DC: 2024) https://doi.org/10.21949/1521490

What Is the EAR Program?

The EAR Program supports longer term, higher risk research with the potential for transformative improvements to the U.S. transportation system. The EAR Program seeks to leverage promising expertise and advances in science and engineering to create breakthrough solutions to highway transportation issues.

REFERENCES

[1]Environmental Protection Agency. 2024. "Reducing Embodied Carbon of Construction Materials through the Inflation Reduction Act" (web page). https://www.epa.gov/greenerproducts/reducing-embodied-carbon-construction-materials-through-inflation-reduction-act, last accessed March 25, 2024.

[2]Ram, P., J. Harvey, S. Muench, I. Al-Qadi, G. Flintsch, J. Meijer, H. Ozer, et al. 2017. *Sustainable Pavements Program Road Map*. Report No. FHWA-HIF-17-029. Washington, DC: Federal Highway Administration. https://www.fhwa.dot.gov/pavement/sustainability/hif17029.pdf, last accessed March 25, 2024.

CONTACT

For more information about this EAR Program project, please contact Nadarajah Sivaneswaran, FHWA Office of Infrastructure Research and Development, at 202-493-3147 (email: nadarajah.sivaneswaran@dot.gov).

LEARN MORE

To learn more about the EAR Program, visit https://highways.dot.gov/research/exploratory-advanced-research. The website features information on research solicitations, updates on ongoing research, links to published materials, summaries of past EAR Program events, and details on upcoming events.

FHWA-HRT-24-056
HRTM-30/07-24(WEB)E

U.S. Department of Transportation
Federal Highway Administration