Cement & Lime Decarbonization DoE Workshop

Office of Fossil Energy and Carbon Management (FECM); Industrial Efficiency & Decarbonization Office (IEDO) and Office of Clean Energy Demonstrations (OCED)

Aron Newman
Group Leader, Infrastructure Materials Group, Engineering Laboratory

Hilton Garden Inn Pittsburgh/Southpointe, Canonsburg, PA
July 19 – 20, 2023

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
U.S. DEPARTMENT OF COMMERCE

Definition of Measurement Science

The term measurement science is used in the context of creating **critical-solution enabling tools – metrics, models, and knowledge** – for U.S. manufacturers, including:

Development of

- Performance metrics
- Measurement and testing methods
- Predictive modeling and simulation tools
- Knowledge modeling
- Protocols
- Technical data
- Reference materials
- Artifacts

- Conduct of inter-comparison studies and calibrations
- Evaluation of technologies, systems, and practices, including uncertainty analysis
- Development of the technical basis for standards, codes, and practices

NIST Laboratory Programs

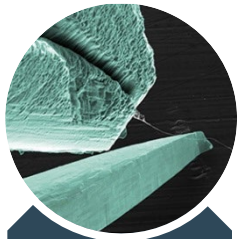
Material Measurement Laboratory

Physical Measurement Laboratory

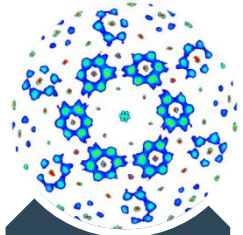
Engineering Laboratory

Information Technology Laboratory

Communication Technology Laboratory



Center for Nanoscale Science and Technology



NIST Center for Neutron Research

Metrology Laboratories

Driving innovation through Measurement Science and Standards

Technology Laboratories

Accelerating the adoption and deployment of advanced technology solutions

National User Facilities

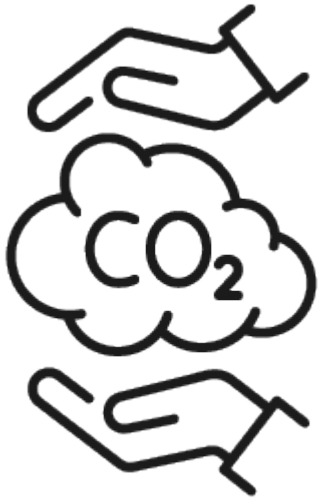
Providing world class, unique, and cutting-edge research facilities

NIST's Carbon Capture Project

NIST, in coordination with industry and other agencies, is developing:

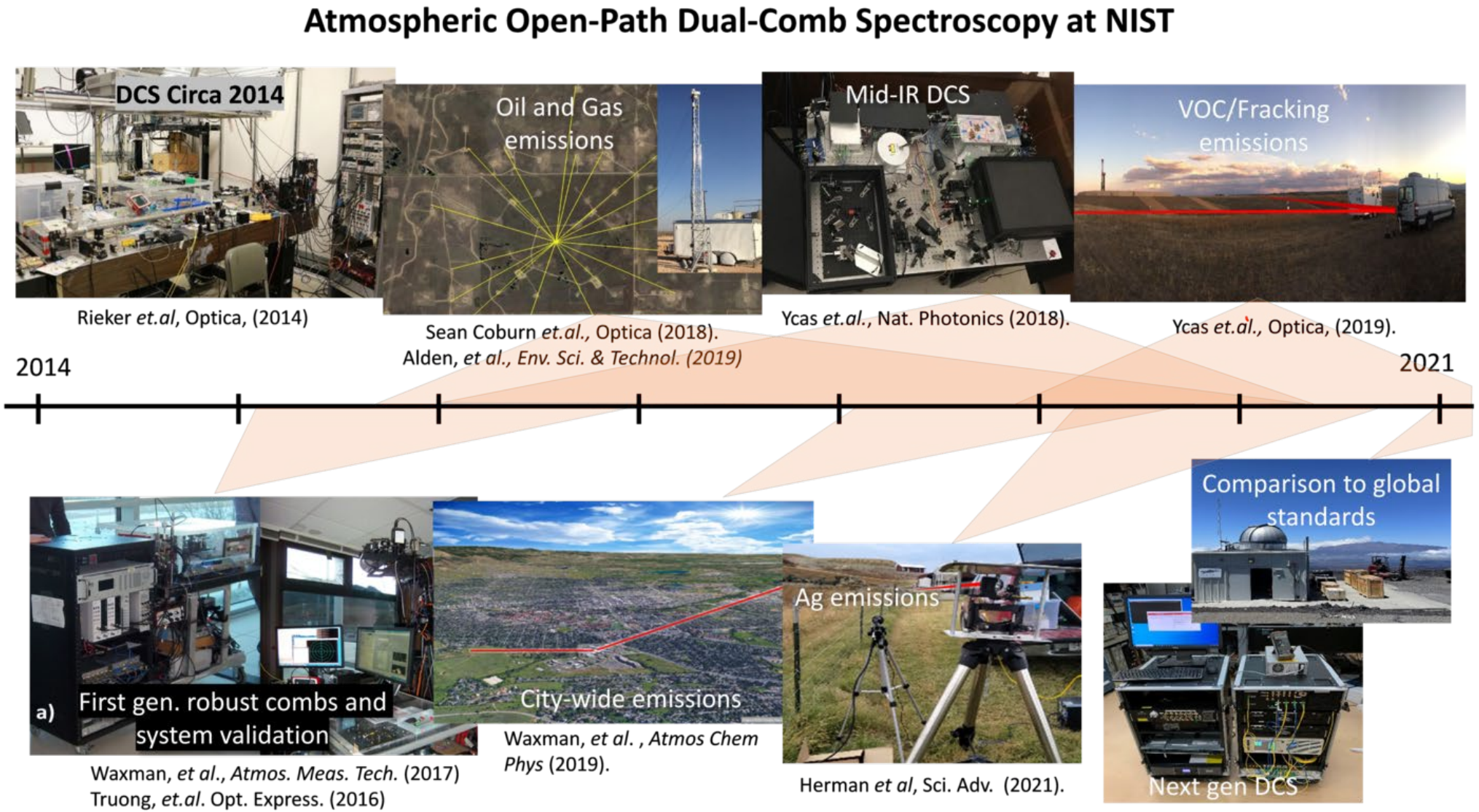
- Benchmark Materials
- Measurements and Data
- Models

Goal: Accelerate innovation in and validate performance of materials and technologies for CDR and CCUS.



https://www.nist.gov/programs-projects/carbon-capture-and-carbon-sequestration

Greenhouse Gas and Atmospheric Trace Gas Measurements



https://www.nist.gov/programs-projects/greenhouse-gas-and-atmospheric-trace-gas-measurements

Low Carbon Cements and Concrete Consortium NIST

Accelerate adoption of innovative low-carbon building materials

Cements & Concretes

Consortium

- 35 member organizations – industry, academics, other agencies
- Coordinate with voluntary consensus standards organizations, e.g. ASTM, ACI
- Coordinate with other agencies EOP/CEQ, DOE, EPA, DOT
- Facilitate standards development, interlaboratory comparisons and research grade test materials
- Performance specifications

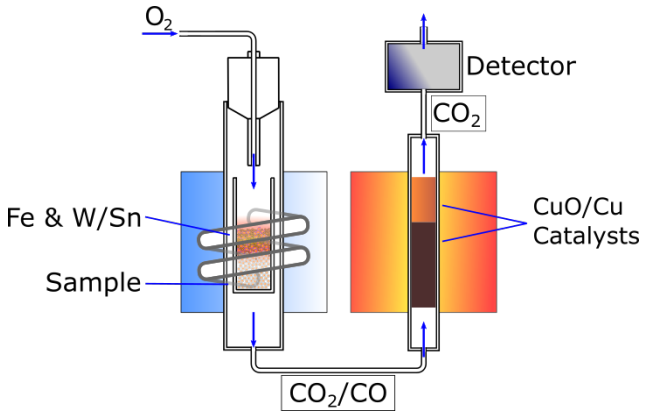
Kinetics of CO_2 uptake

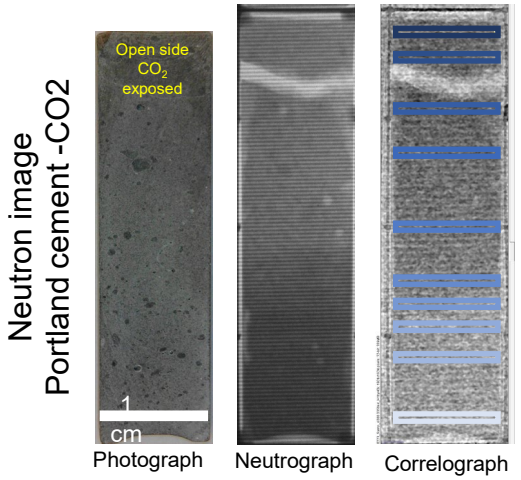
- Neutron imaging, USAX, SAX, XRD

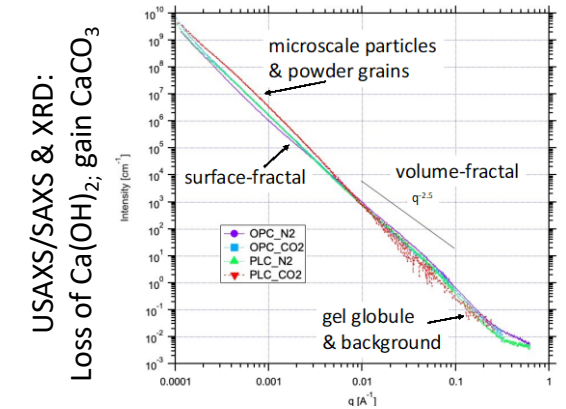
Fostering a Circular Economy and Carbon Sequestration for Construction Materials: A Focus on Concrete - workshop 2022

Low Carbon Cements and Concretes Consortium | NIST

Combustion Analysis







Consortium Members

Argos
Ash Grove
Biomason
Blue Planet Systems
Boise State University
Buchi
Bureau of Reclamation
Carbon Limit
CarbonBuilt
CarbonCure
Dept of Transportation-FHWA
Fortera
Georgia Tech
Georgetown University
Heidelberg Materials
Iowa State University
Kline Consulting, LLC
MIT - Concrete Sustainability Hub
National Ready Mixed Concrete Association
NEU
National Science Foundation
Outside the Box Materials
Portland Cement Association
Purdue University
Solidia Technologies
Spherical Block, LLC
Sublime Systems
Sutter Engineering
St Mary's Cement
UCLA
Ultra High Materials, Inc
University of Miami
University of Texas- Arlington
U.S. Army Corp of Engineers

34 as of 4/26/2023

Consortium Goals

- Evaluate the suitability of current ASTM standards to measure carbon, including specifically measuring carbon in cements, concretes, and the associated starting materials such as aggregates.
- Accurately measure the amount of carbon uptake by a material during CO_2 -curing processes. Validate the robustness and repeatability of the measurement method.
- Use these measurements as a foundation to propose tests(s) that can be standardized through the ASTM consensus process.
- Evaluate the applicability of current material, mechanical, structural, and durability tests used for cements and concretes to new low carbon cements and concretes. If needed, develop new tests or point out why old tests are not needed to help enable acceptance of these new materials in the marketplace.

Consortium In-Person Meeting

Workshop Goals:

1. Identify and develop a comprehensive list of stakeholders.
2. Rate the current engagement level of each stakeholder identified
3. Identify the key barriers and key incentives for implementation for each stakeholder identified.
4. Prioritize stakeholders based on potential impact and ability to engage.
5. Brainstorm ideas for how to monitor, communicate, and engage with each stakeholder group identified.

Breakout:

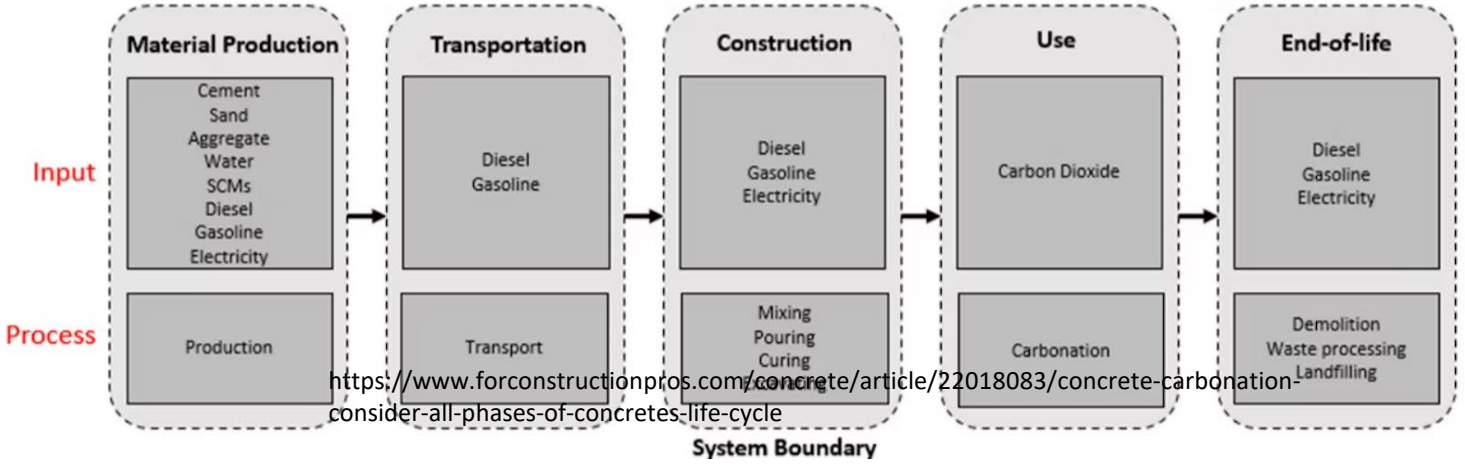
1. Identify the gaps that currently exist in accelerating uptake of low carbon cement and concrete in the marketplace.
2. Discuss key areas where the Consortium can contribute based on gaps
3. Review and further refine Consortium goals
4. Discuss next steps and takeaways

NIST Boulder, July 20-21, 2023

Life Cycle of Concrete

Use:

- IPCC recognized that carbonation is a significant component of the carbon cycle for concrete.
- Challenges to include in LCA due to difficulty in quantifying – factors include: different covers, porosity of concrete, moisture content, cement type and additives, the actual lifetime, etc



https://www.forconstructionpros.com/concrete/article/22018083/concrete-carbonation-consider-all-phases-of-concretes-life-cycle

Intergovernmental Panel on Climate Change (IPCC), May 2021 Board Meeting, https://www.ipcc-nggip.iges.or.jp/EFDB/otherdata/Note_on_Cement_Carbonation.pdf

Mid-Term Strategies - Potential Barriers

- Optimizing clinker substitutes (e.g. portland limestone cement, limestone calcined clay cement, calcium sulfoaluminate, carbonatable calcium silicate cement)
- Switching from coal to lower-carbon fossil fuels for clinker production
- Increasing use of recycled materials in cement (down cycling or circular)
- Promoting market uptake of low-carbon cements and concretes
- Maximizing efficiency in concrete design and construction (less cement in concrete & less concrete in structures)

Barriers to Adoption: cost, single-stream processing, logistics – delivery guarantee, risk due to change, supply chain, safety, quality and durability

https://www.wdscepaniak.com/recycling

Long-Term Strategies – Potential Barriers

- Deploy clinker substitutes and alternative clinker technologies while optimizing for durability (e.g. alkali-activated binders, geopolymers, and magnesium-based cements, alternative rebar)
- Harnessing new energy sources, including clean hydrogen, electricity, and alternative fuels (e.g. biobutanol, dimethyl ether, methanol, renewable diesel, NH_3)
- Maximizing concrete's ability to sequester carbon via a variety of carbon mineralization approaches
- Expand the application space of precast concrete and to leverage new binder chemistries (e.g. design for disassembly)
- Decarbonization of the transport of precursor and final products
- Commercial adoption of carbon capture utilization and storage (CCUS)

Barriers to Adoption: MORE issues with … cost, logistics – delivery guarantee, risk due to change, supply chain, low/zero carbon energy infrastructure in place, safety, quality and durability

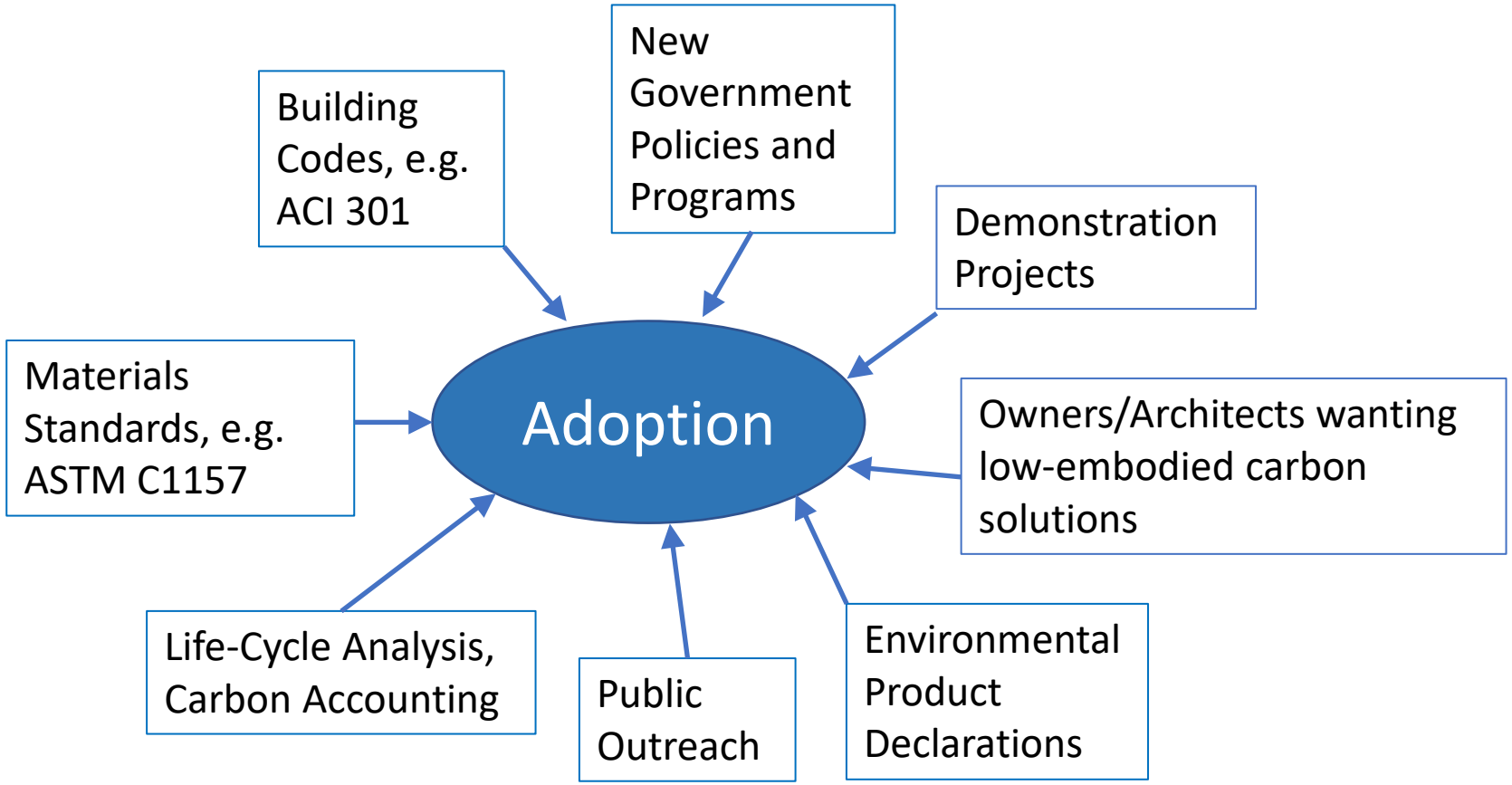
https://www.azobuild.com/article.aspx?ArticleID=8363

https://www.msprecast.com/wall-panels

Towards 2030 and 2050 Goals – Multipronged Approach

Standards Needs:

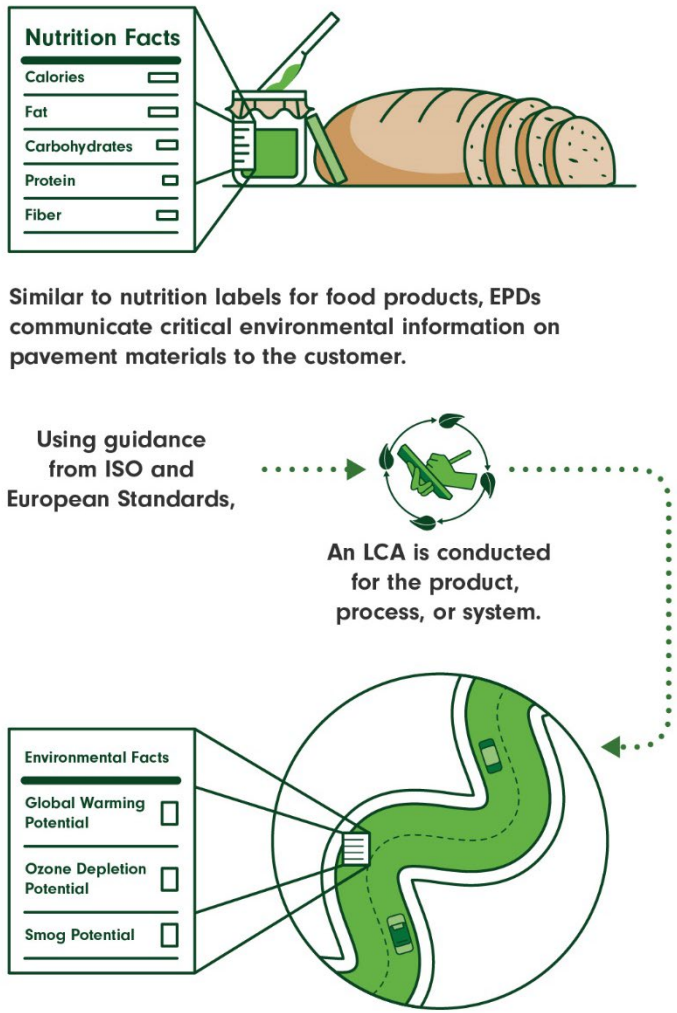
- Be actively involved in standards committee work, including interlaboratory studies.
- Must include representation from producers, owners, and academia.
- Performance-Based Standards instead of Prescriptive-Based Standards



Suitability of EPDs for Supporting Life Cycle and Comparative Analysis of Concrete Mixtures
DOI: 10.1021/acs.est.2c05697

What Are EPDs?

- Communicate environmental impacts of material or product.
- Express the results of an LCA.
- Developed with stakeholder input.
- Follow industry standards described in the PCR.
- EPDs are not required by Federal law or regulation.



Source: FHWA.

Roadmaps

https://gccassociation.org/concretefuture/

https://thisisukconcrete.co.uk/TIC/media/root/Perspectives/MPA-UKC-Roadmap-to-Beyond-Net-Zero_October-2020.pdf

https://www.cement.org/sustainability/roadmap-to-carbon-neutrality

https://ised-isde.canada.ca/site/clean-growth-hub/en/roadmap-net-zero-carbon-concrete-2050

https://www.iea.org/reports/technology-roadmap-low-carbon-transition-in-the-cement-industry

https://www.third-derivative.org/blog/low-carbon-cement-2

https://www.aceee.org/sites/default/files/pdfs/u2202.pdf

https://rmi.org/insight/roadmap-to-reaching-zero-embodied-carbon-in-federal-building-projects/

https://par.nsf.gov/servlets/purl/10301626