Life Cycle Assessment Decision Making: Data and Tools

Updates on FHWA Initiatives and Asphalt Industry LCA Model

International Society of Asphalt Pavements

November 17, 2022

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Climate Challenge Team
Office of Infrastructure, FHWA

Environmental Product Declaration NAPA CERTIFIED

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NAPA NATIONAL ASPHALT PAVEMENT ASSOCIATION

U.S. Department of Transportation Federal Highway Administration

SUSTAINABLE PAVEMENTS PROGRAM

Outline

Background

FHWA Framework

Collaboration with Federal LCA Commons

PCRs & EPDs

Fundamentals
PCR Guideline Toolkit
Asphalt Industry LCA

LCA Updates

Towards NetZero
Discussion

Looking Ahead

Climate Challenge

Applications

LCA PAVE

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CARBON NEUTRAL ZERO EMISSION CARBON NEUTRAL

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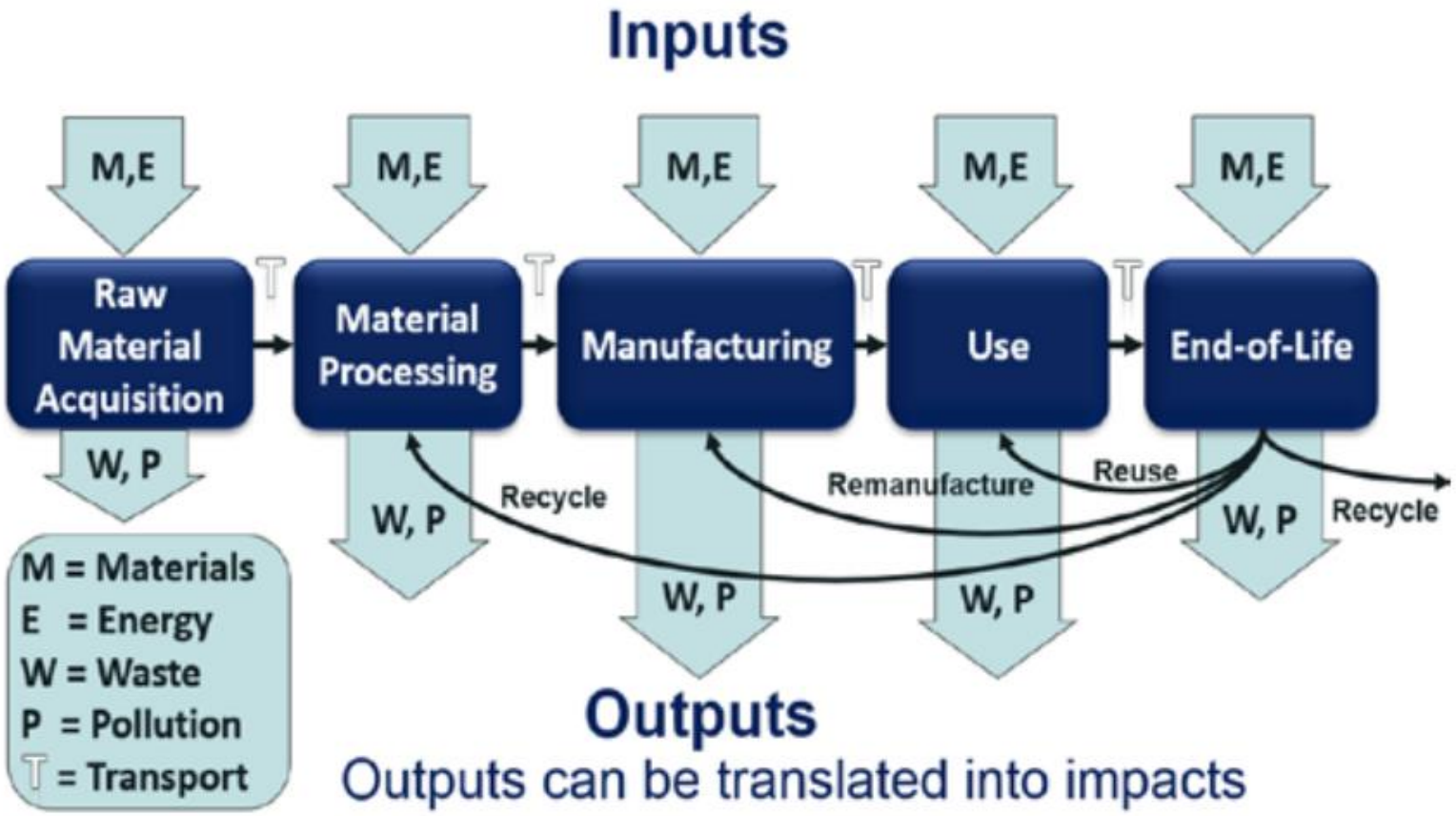
WAP SUSTAINABILITY CONSULTING

U.S. Department of Transportation Federal Highway Administration

Life Cycle Assessment (LCA)

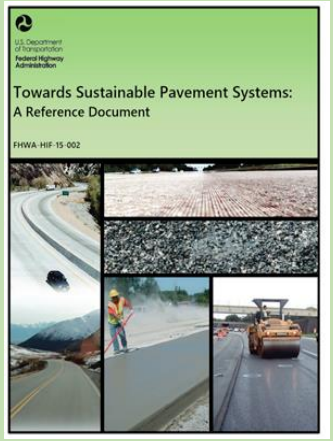
- What is the driving question?
- What is being included within the system boundaries?
- Scope of the study depends on the goal

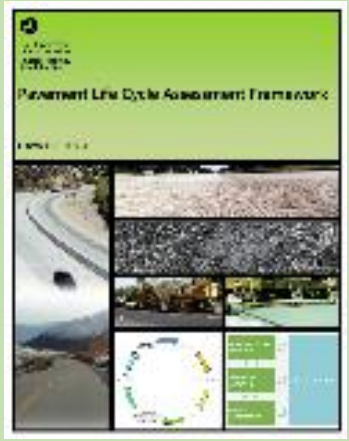


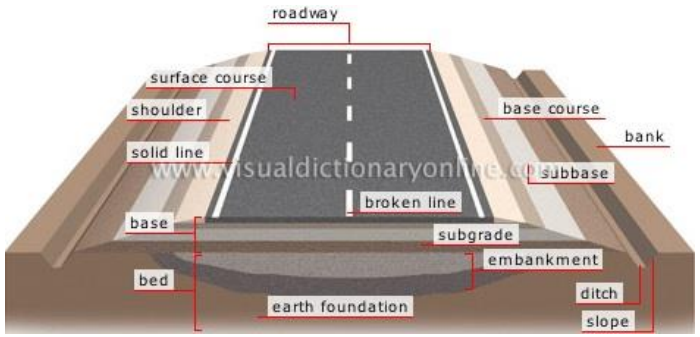
Generic life cycle of a production system for LCA (Kendall 2012).

Sustainable Pavements

Guidelines and framework (2015)
- System boundaries
- Unit processes







- Product Systems
- Flows
- Processes
- Who is the stakeholder?

Class | Sub-class | Inherent Properties | Specific Properties

Flows | Process

Development of an Ontology

Development of information models

```
org.openlca.core.model
Class Flow
  java.lang.Object
    org.openlca.core.model.AbstractEntity
      org.openlca.core.model.RootEntity
        org.openlca.core.model.CategorizedEntity
          org.openlca.core.model.Flow

public abstract class Materials extends Flow {
        // declare fields
        // declare nonabstract methods
}

Public class AsphaltMixture extends Materials {
        // declare asphalt mixture specific fields
        // declare asphalt mixture methods
}
```

```
org.openlca.core.model
Class Process
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public abstract class ProductionProcess extends Process {
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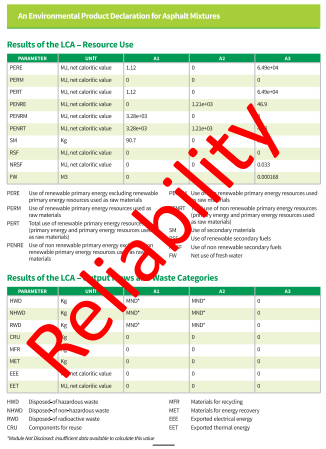

Federal LCA Commons

National Energy Technology La
U.S. Life Cycle Inventory Database
USDA LCA Commons
EPA
Argonne NATIONAL LABORATORY
NATIONAL ENERGY TECHNOLOGY LABORATORY
NREL NATIONAL RENEWABLE ENERGY LABORATORY
USDA
U.S. Department of Transportation Federal Highway Administration
theRightenvironment

Mapping to Public Background Data

Electricity

Source : National Energy Technology Laboratory

Data Quality : *File*

Fossil Fuels and Non-Renewables

Source : National Renewable Energy Laboratory

Data Quality : *File*

Transportation

Source : National Renewable Energy Laboratory

Data Quality : *File*

Construction Equipment

Source : United States Environmental Protection Agency

Data Quality : *File*

Asphalt

Asphalt Binder

Source : Asphalt Institute and NAPA

Data Quality : *File*

Concrete

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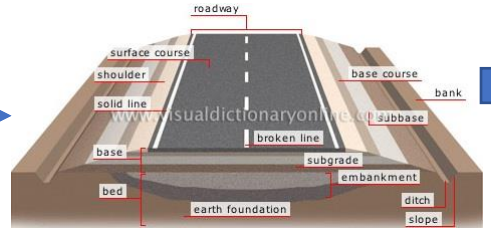
Background Data

- *Fuels*
- *Electricity*
- *Transportation*

Source: (Visualdictionaryonline.com, 2019)



Pavement

End-Of-Life

EPA United States Environmental Protection Agency

USDA LCA Commons USDA

Source : United States Environmental Protection Agency

Data Quality : *File*

LCA PAVE

Arizona DOT Case Study: LCA Pave Application

Investigate the feasibility of integrating Life Cycle Assessment (LCA) information for supporting pavement design decision-making, procurement and pavement management processes.

Compare Alternative Treatments

- Mill & Fill
- Hot in Place Repaving
- Full Depth Reclamation

Hot-in-Place Repaving

Removal: Cold mill of ¾-inch

Paving: 3 inches total,

- 1-inch Hot in Place
- 1-1/2-inch new asphalt concrete (AC)
- ½-inch new AC friction course (ACFC).

Mill & Fill

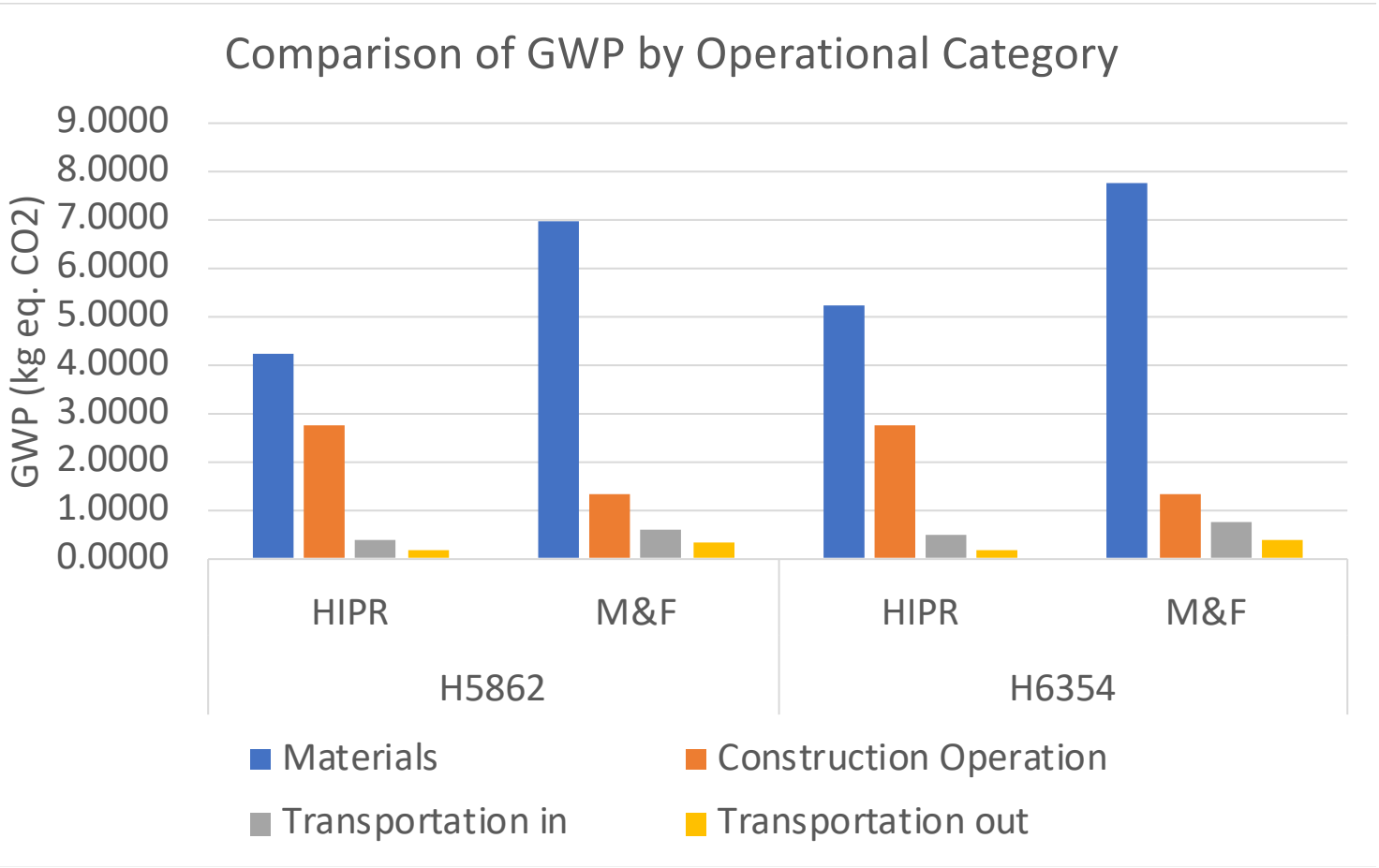
Removal: cold mill 1-3/4 inch

Paving: 3 inches total

- 2-1/2 inch of new AC,
- ½ inch of new ACFC.

LCA PAVE

Comparison - GWP

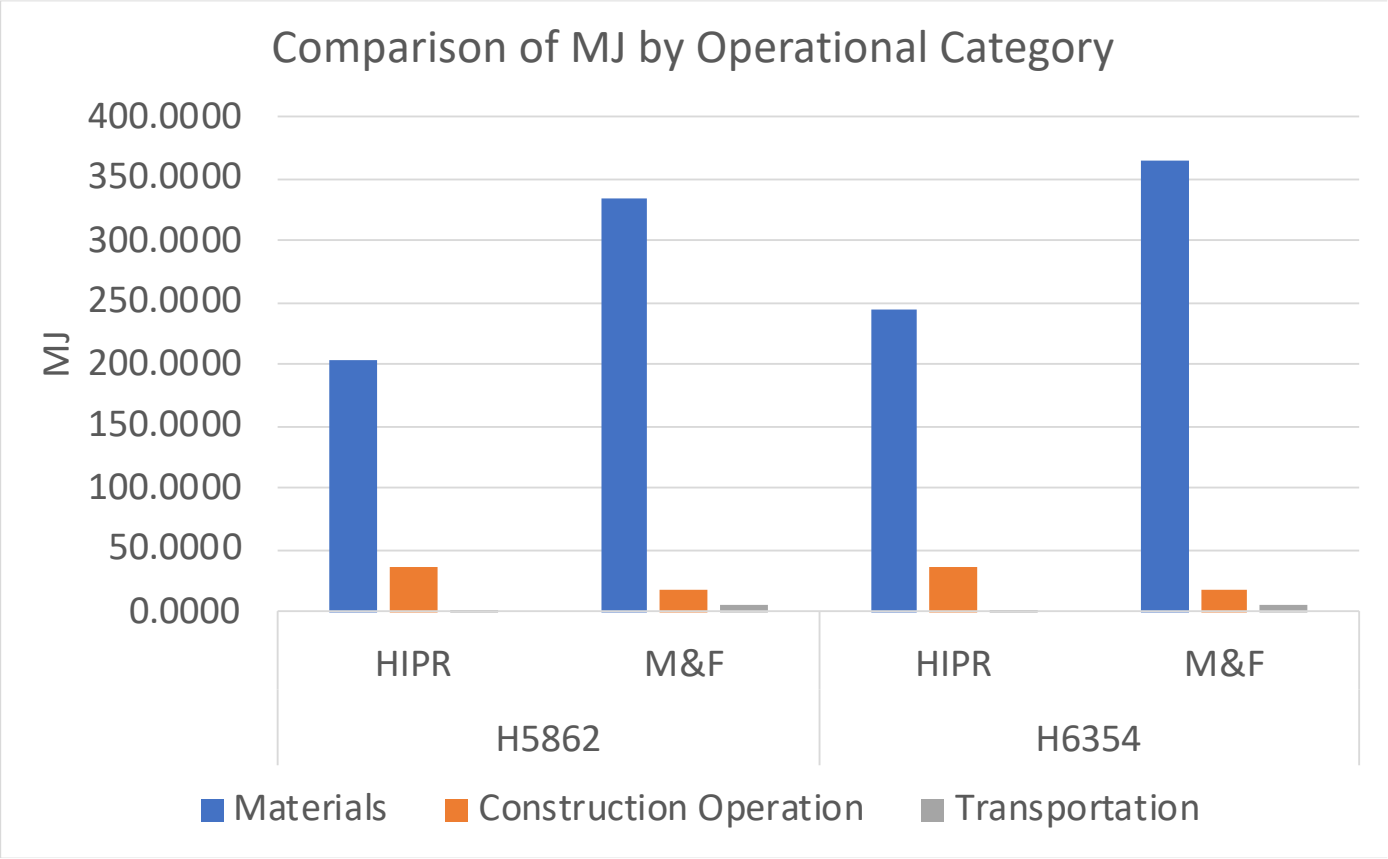


HIPR: 7.5494 kg of CO2 Eq./sq yd

M&F: 9.2918 kg of CO2 Eq./sq yd

- Impact from new material use drives GWP
- HIPR is a lot more energy intensive during construction

Comparison - Energy



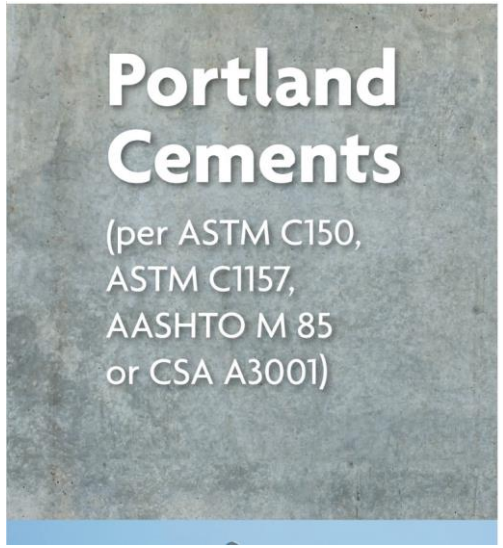
HIPR: 242.42 MJ/sq yd

M&F: 359.68 MJ/sq yd

- Net energy impact from new material governs
- Transportation of milling off site not a contributor – in this case

How do we Communicate LCA Outcomes?

Product Category Rules and Environmental Product Declaration



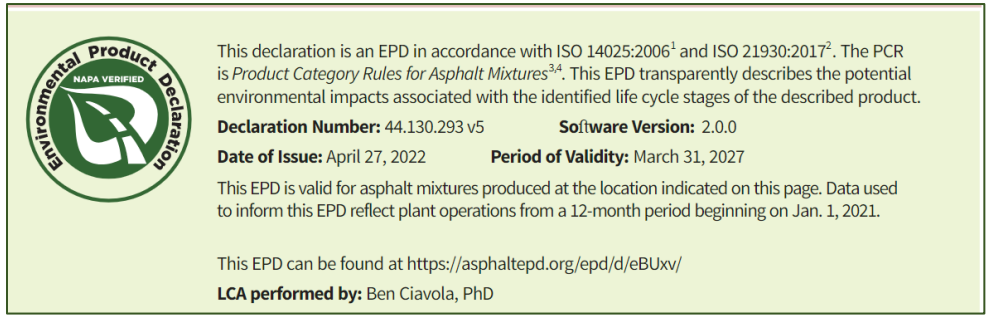
Product Category Rules

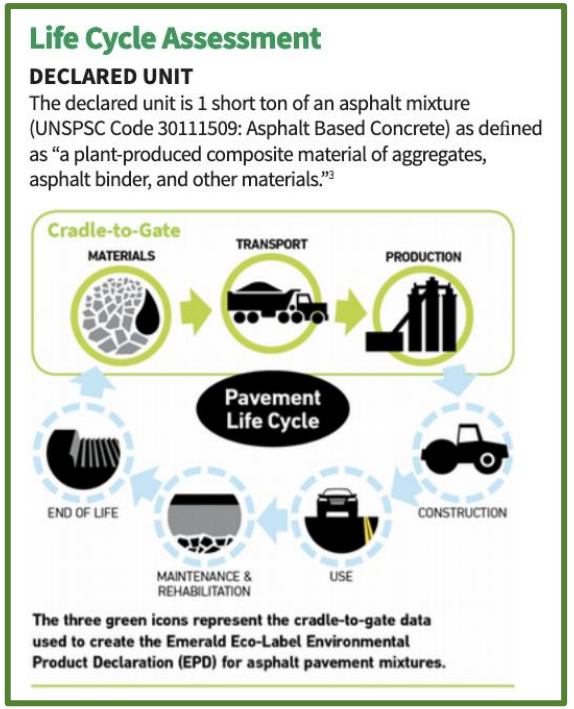
PCR Principles and Procedures: ISO 14025
Core PCR (part A): ISO 21930

Rules that govern LCA supporting an Environmental Product Declaration (EPD)

A PCR specifies:

- The goal, scope
- Functional and/or declared units
- The modules and processes
- Guidelines for data collection
- Time horizon of reporting
- Use of geographically pertinent data.





Background Data

- Fuels
- Electricity
- Transportation

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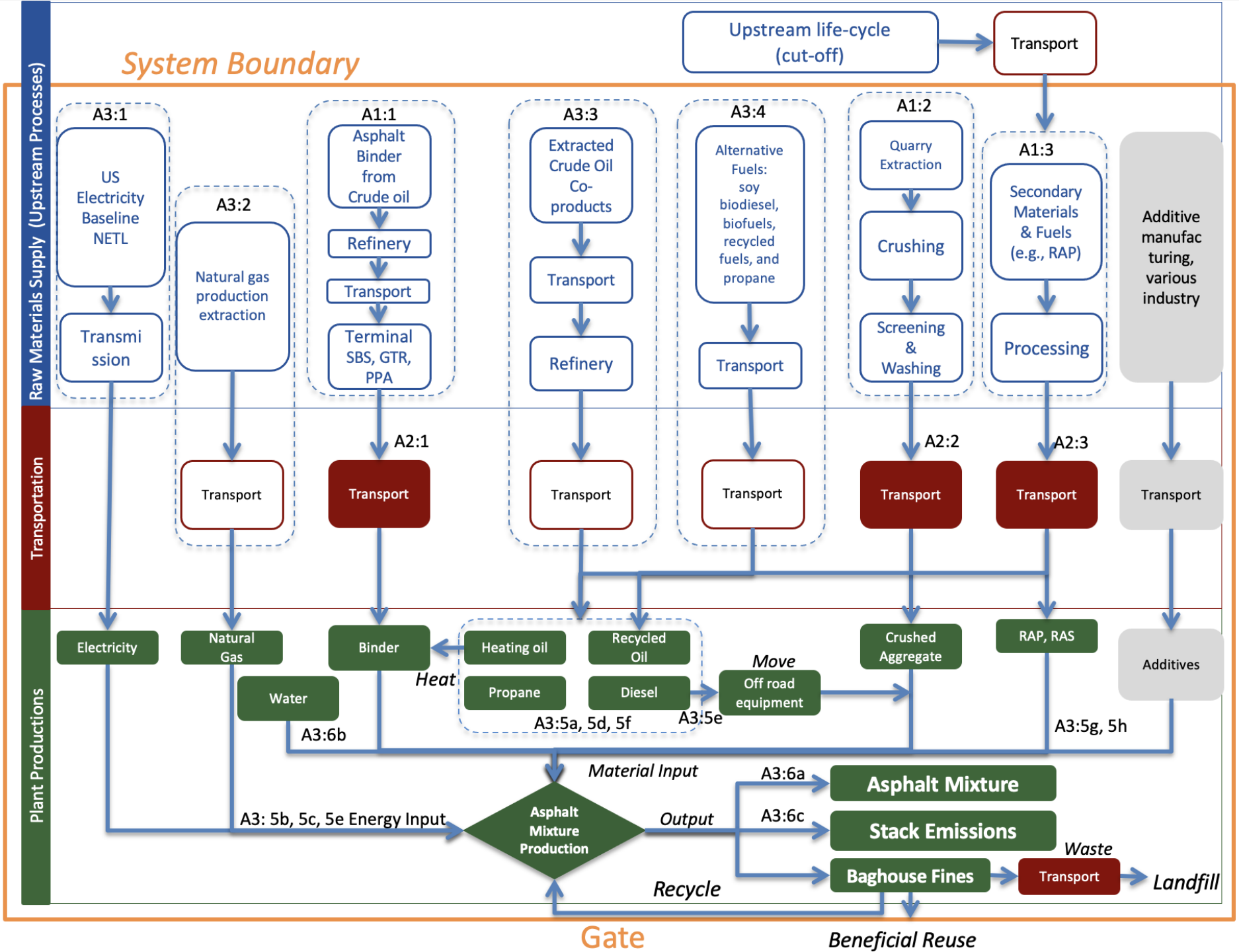
Environmental Product Declarations

Standard instrument to reporting LCA outcomes based on a Product Category Rule

- ✓ Environmental impact indicators (such as Global Warming Potential),
- ✓ Total primary energy consumption and material resource consumption.

TABLE 3. ENVIRONMENTAL IMPACT SUMMARY TABLE

IMPACT CATEGORY	POTENTIAL IMPACT PER METRIC TONNE ASPHALT MIXTURE (PER TON ASPHALT MIXTURE)
Global warming potential (GWP-100)	*67.09 (60.87) kg CO2 Equiv.*
Ozone depletion potential (ODP)	*8.33e-08 (7.55e-08) kg CFC-11 Equiv.*
Eutrophication potential (EP)	*1.22e-02 (1.11e-02) kg N Equiv.*
Acidification potential (AP)	*1.99e-01 (1.81e-01) kg SO2 Equiv*
Photochemical ozone creation potential (POCP)	*4.34 (3.94) kg O3 Equiv.*



Scope: Cradle-to-grave

Improved Background Data sets

Foreground Data supported by EPD data collected 2016 – 2020

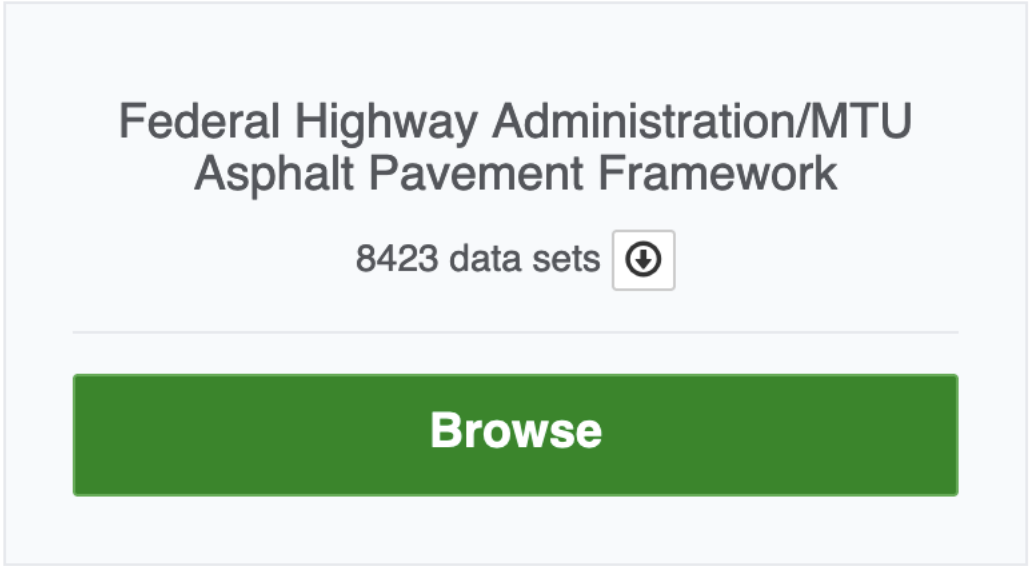
Portable Plants included

Baghouse fines: waste to landfill and beneficial reuse

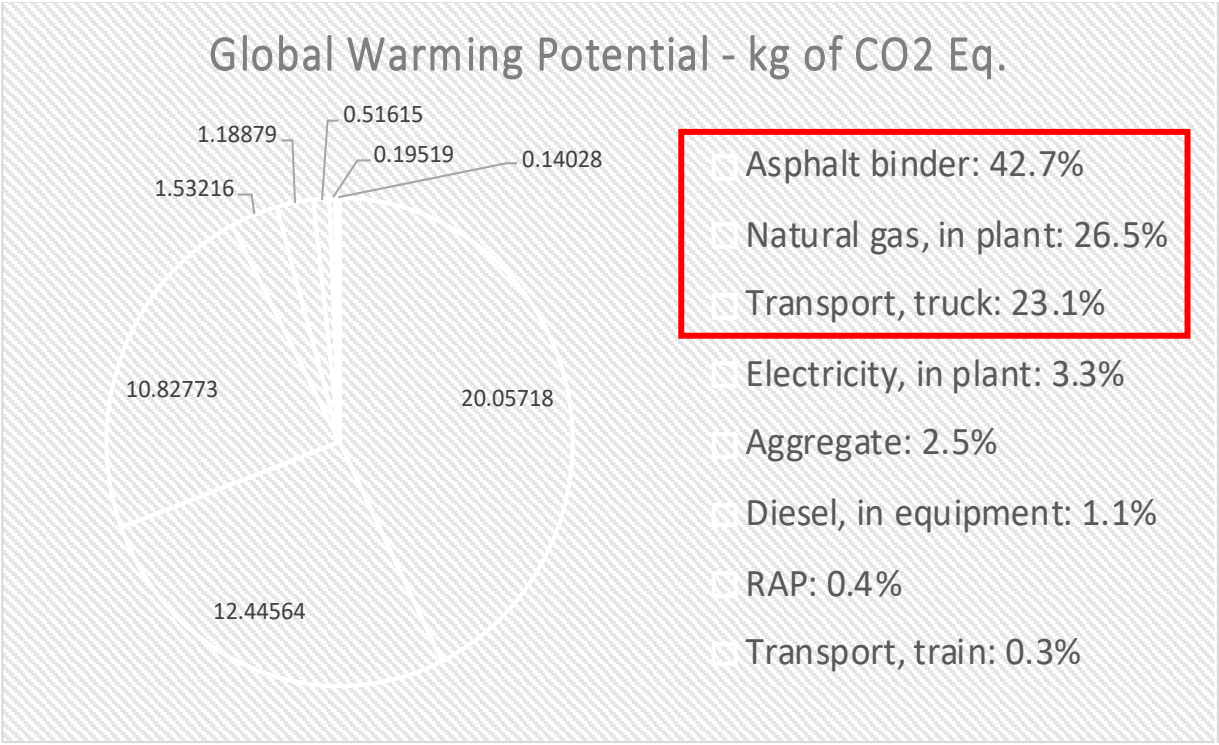
Extended sensitivity analysis

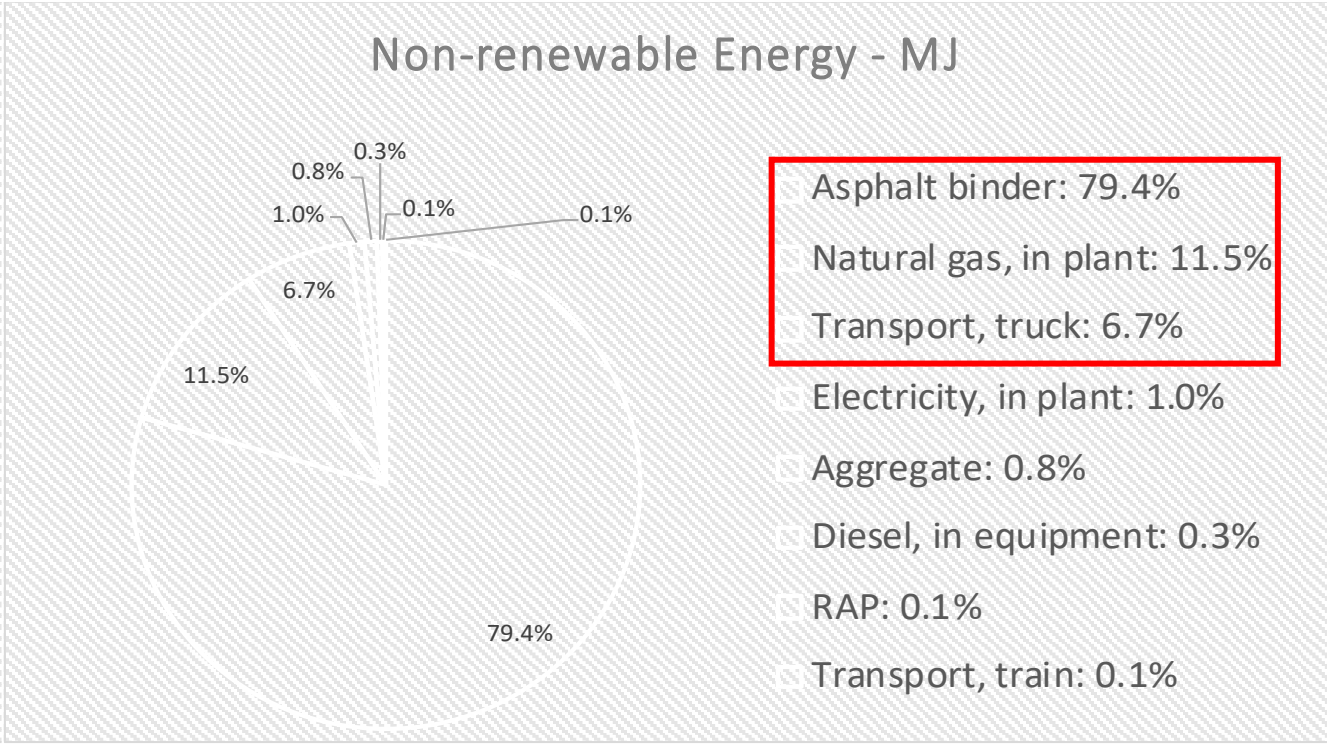
Inventory Status

- Parameterized life cycle inventory available on FLCAC in .zolca (OpenLCA) format
- Life cycle information models:
  - Background data included
  - Impact assessment methods, including for waste and water
  - Foreground data as reported in parametric form - **customizable**



Analysis of Mix Contributions





Mix with 5% asphalt binder, 30% RAP

Average ton-miles travelled (sample of 15 plants):

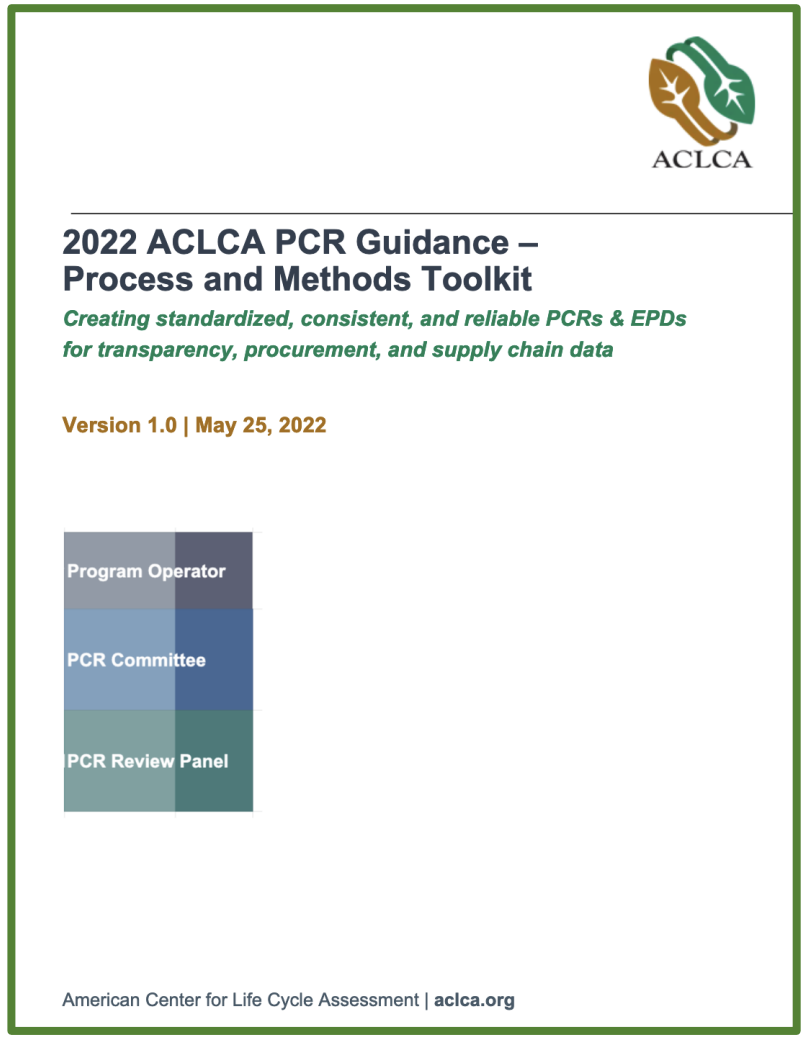
- Truck: Aggregate: 21.5 ton-miles/ton, RAP: 50 ton-miles/ton
- Binder: 3.9 ton-miles/ton (Rail)

Structure of PCR Guidance Toolkit

Program Operator Decides Program Implementation Plan

PCR Committee Decides LCA Framework Models and Assumptions

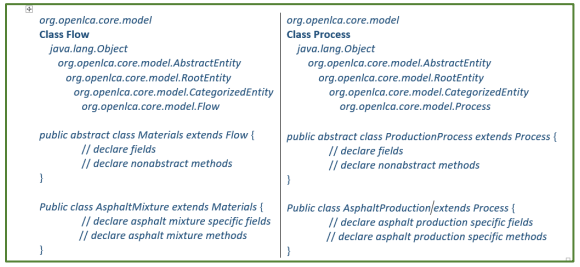
Reviewer Decides Conformance



Outcomes

Formal Definitions for Pavement LCA Framework

Specification for Software Architecture



```
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Class Flow                                Class Process
  java.lang.Object                          java.lang.Object
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      org.openlca.core.model.RootEntity         org.openlca.core.model.RootEntity
        org.openlca.core.model.CategorizedEntity    org.openlca.core.model.CategorizedEntity
          org.openlca.core.model.Flow               org.openlca.core.model.Process

public abstract class Materials extends Flow {    public abstract class ProductionProcess extends Process {
        // declare fields                             // declare fields
        // declare nonabstract methods                // declare nonabstract methods
}                                                 }

Public class AsphaltMixture extends Materials {   Public class AsphaltProduction extends Process {
        // declare asphalt mixture specific fields        // declare asphalt production specific fields
        // declare asphalt mixture methods                // declare asphalt production specific methods
}                                                 }
```

Publication: Bhat et al. (2021)

openLca

Background Data

- *Fuels*
- *Electricity*
- *Transportation*

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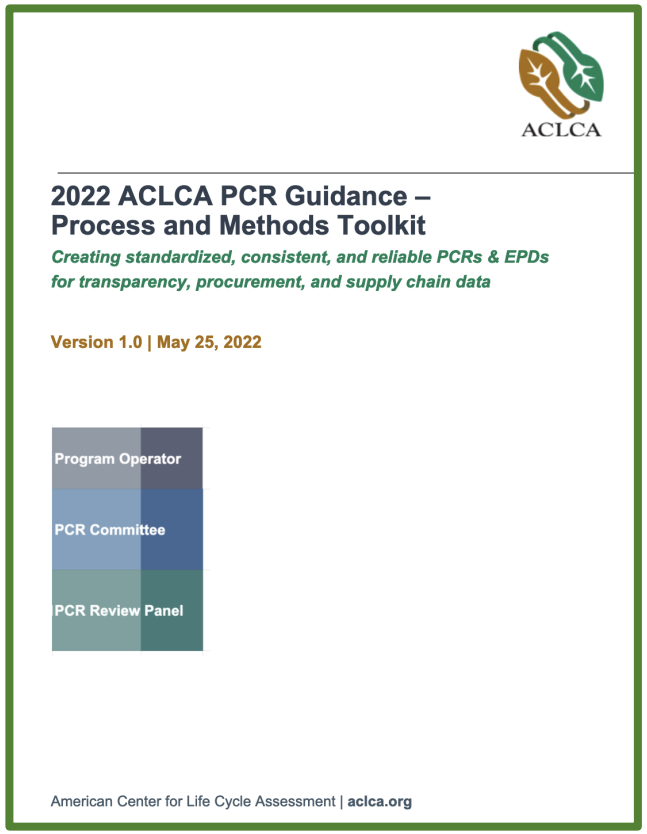


ACLCA

2022 ACLCA PCR Guidance – Process and Methods Toolkit

Creating standardized, consistent, and reliable PCRs & EPDs for transparency, procurement, and supply chain data

Version 1.0 | May 25, 2022

Program Operator

PCR Committee

PCR Review Panel

American Center for Life Cycle Assessment | **aclca.org**

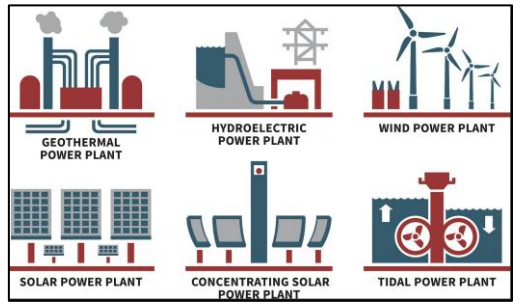
Decision Making

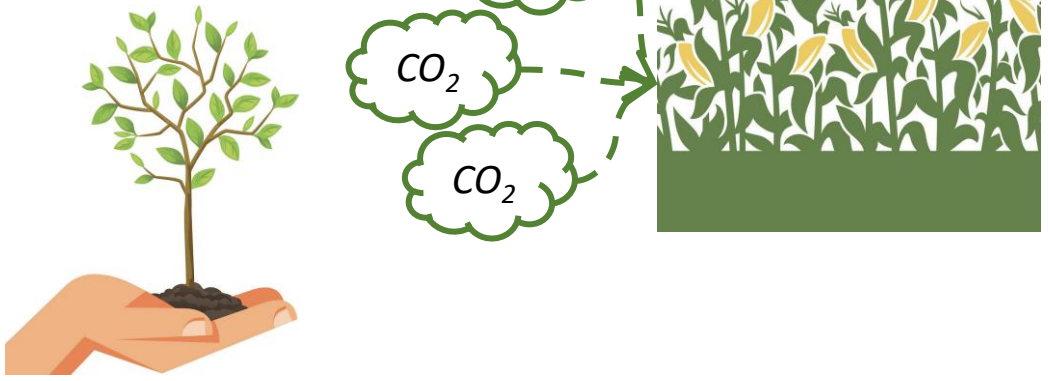
Use Cases

Integration of LCA Metrics in Decision-Making

Pathways to NetZero

- Decarbonization: Choice of Materials
  - Lower embodied carbon
  - Use of recycled materials
- Process Design: Lean engineering
- Onsite Generation of Renewable Energy: Solar, Geothermal, Wind
- Use of bio-based binders and fuels can introduce a negative carbon account due to biogenic uptake
- Use of Offsets: including Renewable Energy Credits
- Towards Consequential LCAs





FHWA Program Updates

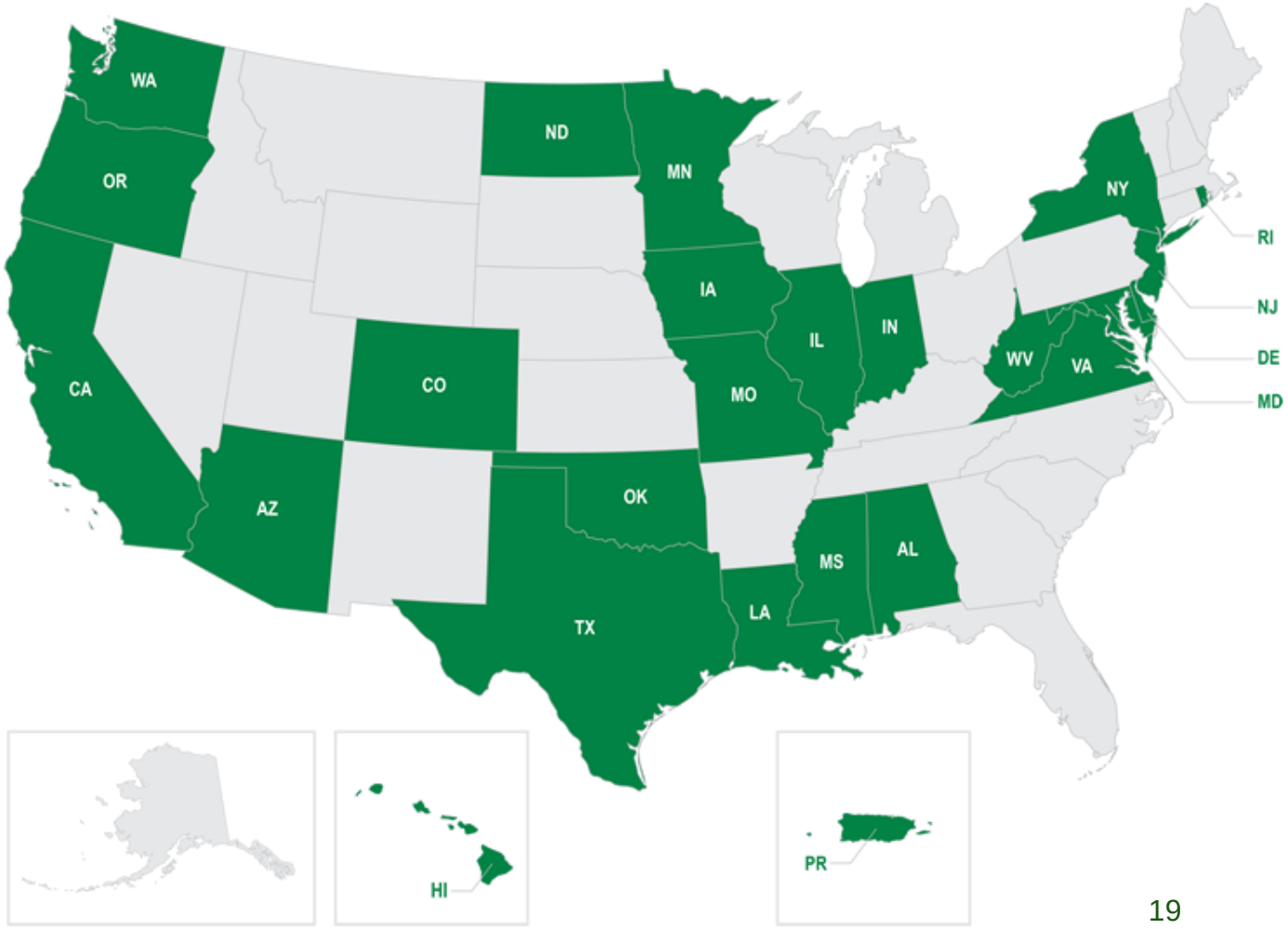
Climate Challenge

EPDs for Advancing Project Delivery

U.S. Department of Transportation
Federal Highway Administration

Climate Challenge Participants

- 30+ proposals from 27 agencies (including 2 local agencies)
  - Education, implementation, benchmarking, fundamental research projects
- Providing technical and funding ($7.1 million) assistance



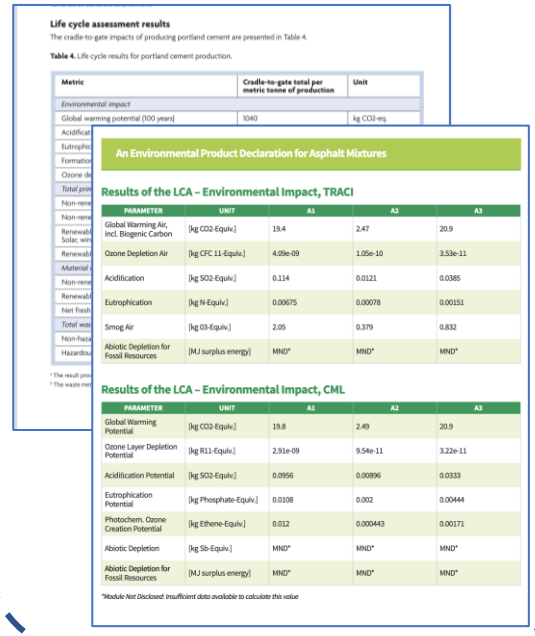
Construction Stage Data Mapping

Procurement Process

Construction Phase

Cradle-to-Gate Impacts

Background Data
Federal LCA Commons



Product & Plant Specific EPDs

+

Foreground Data
Observed Construction Data

+

LCA PAVE

LCA Metric
GWP per sq yd of Operation

Construction Stage Data

Calculation	Source
Asphalt tonnage per yd^2 of asphalt mixture	From bid tabs
Fuel used = total yd^2 * consumption rate	From bid tabs and equipment parameters
Fuel used = sum of all fuel consumed by equipment	From bid tabs and equipment parameters
Tack Coat and Rejuvenator tonnage per yd^2	Bid tabs
Propane used per yd^2 recycling	From contractors and equipment parameters
Transportation distance * ton per yd^2	Assumed 30 mile distance

Synergy: Materials and Specifications

- Quantifying GHG emissions of different mixture designs
- Focus on PEM, BMD recycled materials, WMA & bio-based materials
- Collect asphalt & concrete construction data in OpenLCA format

Synergy: Pavement Performance and Materials

- Use of EPDs in the context of “whole pavement LCA”
- Pavement deterioration modeling and pavement LCA
- Use phase implications
- Long life pavements

Synergy: DOT Processes, Industry Capacity

- Collecting EPDs and integration of life cycle thinking in DOT business processes
- Supporting industry to develop capacity
- Establishing strategic action plans based on readiness assessment

Execution Phase

Programmatic cohesion through:

- Providing technical assistance
- Coordinating peer exchange through the Community of Knowledge
- Fostering synergy in research and development through the Community of Scholars

Expected outcomes:

- Education and implementation practices for agencies and practitioners
- Framework life cycle inventories in the LCA Commons for classes of construction activities
- Research outcomes archived and disseminated through workshops

Training / Workshop

- Educational Outreach
  - LCA and EPD assistance for all Climate Challenge Participants
  - Demonstration and support for use of FHWA LCA Pave Tool
- Dissemination and knowledge transfer
  - Project close out meeting and final symposium
- Integration with FHWA Community of Knowledge
  - Ongoing knowledge sharing and peer support

Contact Migdalia Carrion
Migdalia.carrion@dot.gov

Next Community of Knowledge:
February 2023

Additional Technical Assistance Community of Scholars

- Knowledge development peer exchange group
  - Faculty, graduate students, researchers (open to all)
- Coordinated effort based on following values:
  - Consistency:
    - Use of consensus-based protocols
    - Development of life cycle information models
  - Adaptability:
    - Use of open standards and platforms

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Public Data

- Open data
- Sourced federally or from proprietary sources
- Transparent

Industry

Community of Scholars Topics

- Construction stage data collection protocols
  - Consensus based development
  - Implementation for data collection on construction projects
  - Data organization and reporting
  - Development of repositories
- Development and adoption of standards and frameworks
  - Liaising with organizations: AASHTO
  - Integration with other FHWA tools
  - Developing standardized inventories for use: LCA Commons

SUSTAINABLE PAVEMENTS PROGRAM

U.S. Department of Transportation
Federal Highway Administration

Arizona DOT

ADOT

Contact Information:

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☎:*480-202-6050*

AZ DOT Pavement materials and performance - the use of LCA, PCRs, and EPDs to quantify resource use, energy, emissions and inform design selection processes.

Project Goals:

(1) Explore the current PCR/EPD framework by utilizing a life cycle assessment approach.
(2) Use and expand the role of the long-term performance prediction tools (FlexMAT, FlexPAVE, PassFlex, PassRigid, etc.) and the LCA Pave Tool.
(3) Inform ADOT's implementation plan for reducing carbon emissions from pavements.
(4) Advance FHWA, AZ DOT, academic, and industry awareness

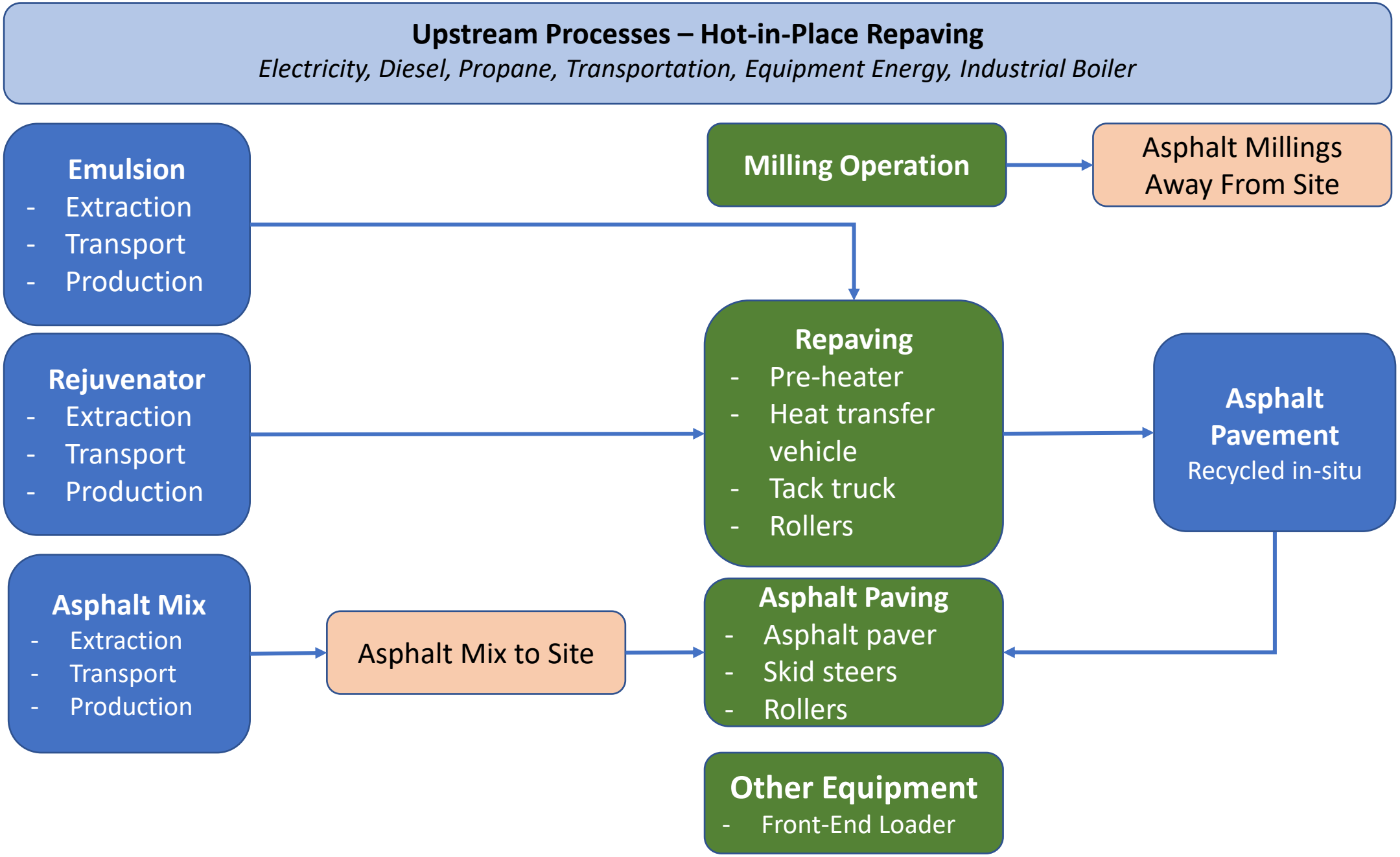
Project Scope:

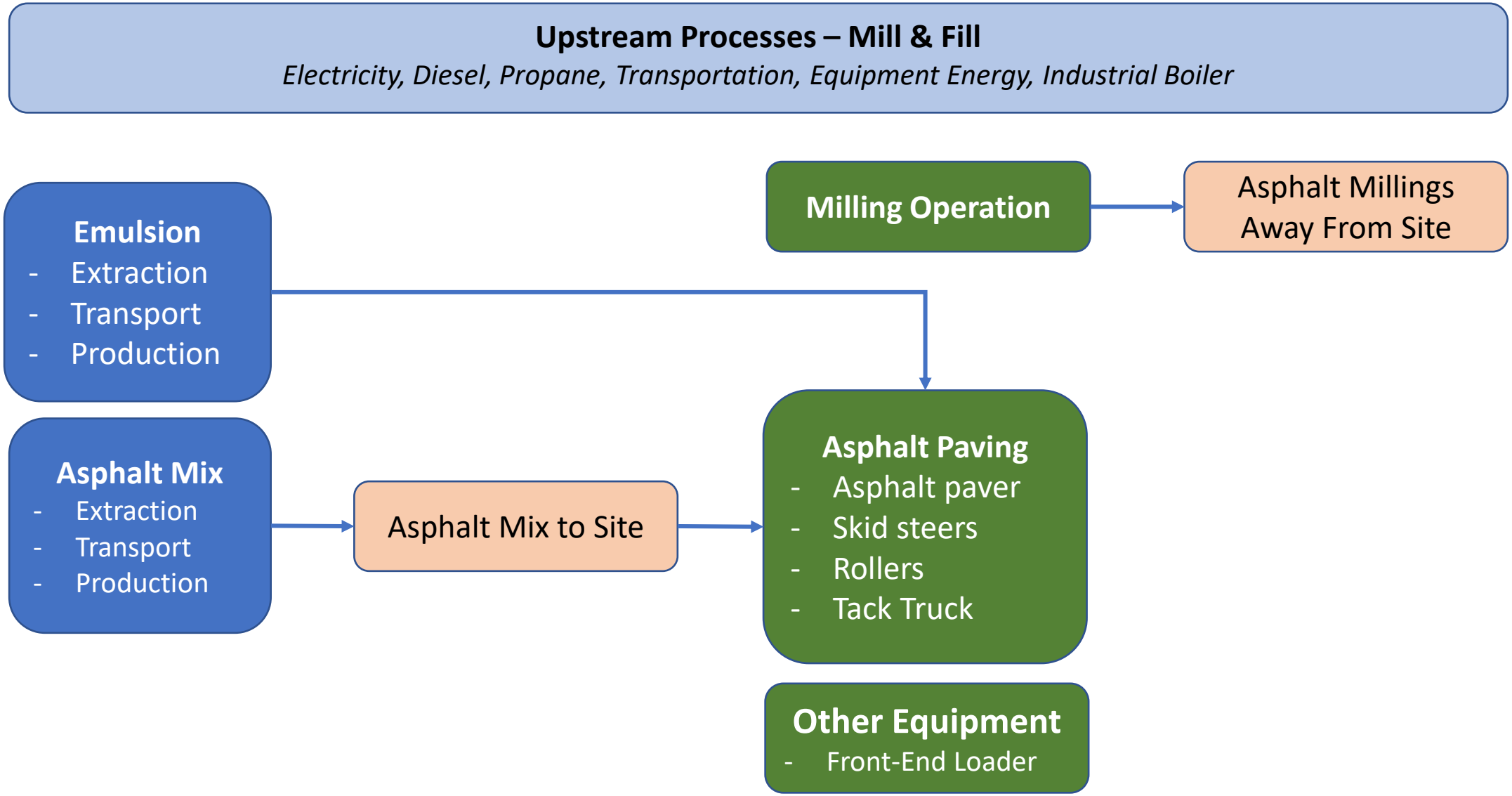
- Develop or refine current standards and specifications to implement quantifiable sustainable pavements approach;
- Implement FHWA LCA Pave Tool to conduct LCAs;
- Collect EPDs on projects;
- Use life cycle inventories from LCA Commons Database to conduct LCA on select projects;
- Implement pilots for techniques, strategies, and materials that reduce GHG emissions;

If you want to go fast go alone,
If you want to go far go together.

- Wisdom of the Ancients

Thank You


Upstream Processes – Hot-in-Place Repaving
Electricity, Diesel, Propane, Transportation, Equipment Energy, Industrial Boiler
Emulsion
- Extraction
- Transport
- Production
Rejuvenator
- Extraction
- Transport
- Production
Asphalt Mix
- Extraction
- Transport
- Production
Asphalt Mix to Site
Milling Operation
Asphalt Millings Away From Site
Repaving
- Pre-heater
- Heat transfer vehicle
- Tack truck
- Rollers
Asphalt Paving
- Asphalt paver
- Skid steers
- Rollers
Other Equipment
- Front-End Loader
Asphalt Pavement
Recycled in-situ
Materials
Transportation
Operations
Transportation


Upstream Processes – Mill & Fill
Electricity, Diesel, Propane, Transportation, Equipment Energy, Industrial Boiler
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