Sustainability Strategies for Flexible Pavements

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Outline

- Sustainability: Where did it all start?
- Sustainability and Pavements
- Life-Cycle Assessment (LCA) Approach
- Sustainability Strategies
  - What are these?
  - How have they been evaluated?
  - Next steps?

US DOT is Committed to Advancing Sustainability

- DOT will incorporate sustainability principles into our policies, operations, investments and research through innovative initiatives and actions such as:
  - Infrastructure investments and other grant programs,
  - Innovative financial tools and credit programs,
  - Rule- and policy- making,
  - Research, technology development and application,
  - Public information, and
  - Enforcement and monitoring.

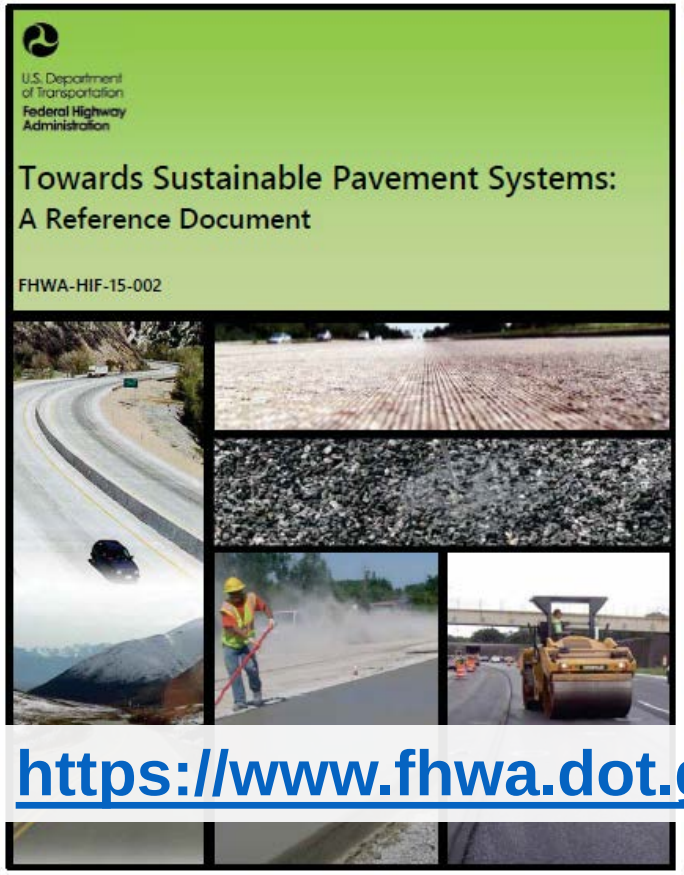
Policy Statement

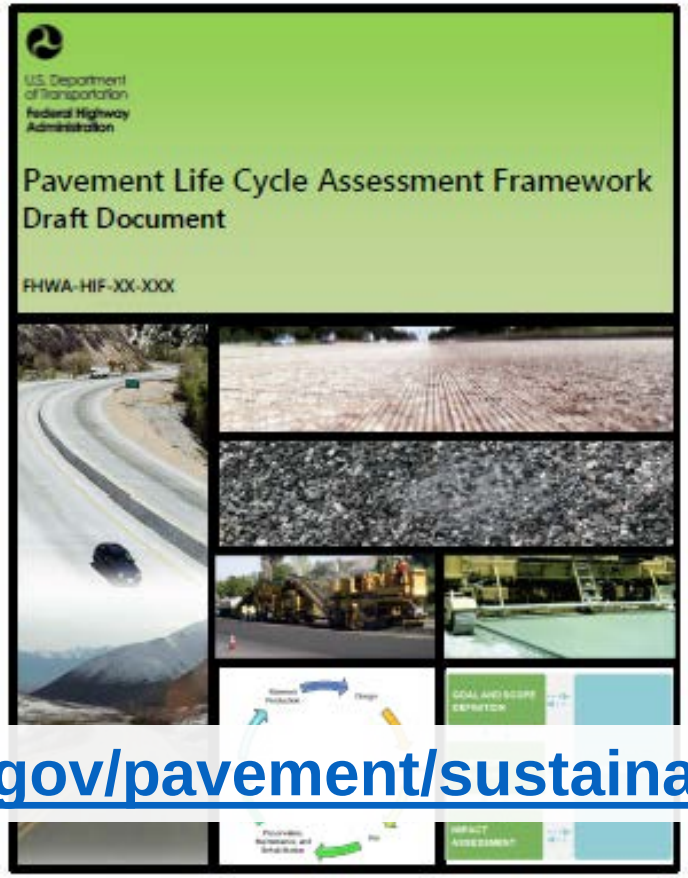
Signed Secretary Anthony R. Foxx, June 2014

U.S. Department of Transportation
Federal Highway Administration

Sustainability Programs and Efforts

- FHWA Sustainable Pavements Program
  - First phase 2010-2015
  - Second phase covering 2015-2020





- Webinars
- Tech Briefs
- Technical Working Group (TWG) Meetings

https://www.fhwa.dot.gov/pavement/sustainability/

Sustainable Pavements

"Sustainable" in the context of pavements refers to system characteristics that encompasses a pavement's ability to:

- **Achieve the engineering goals for which they are constructed**
- **Use resources wisely (money + natural)**
- **Preserve and restore surrounding ecosystems**
- **Meet basic human needs such as health, safety, employment, and comfort**

Sustainability Metrics and Tools

- Performance assessment
  - Evaluate performance vs. intended function
  - Metrics: distress, thickness, material attributes
- Life-cycle cost analysis (LCCA)
  - Total user and agency costs over its life-cycle
- Life-cycle assessment (LCA)
  - Environmental burden of a pavement from cradle to grave
  - Environmental burden of producing asphalt mixture
- Rating systems
  - A list of sustainability best practices with a common metric

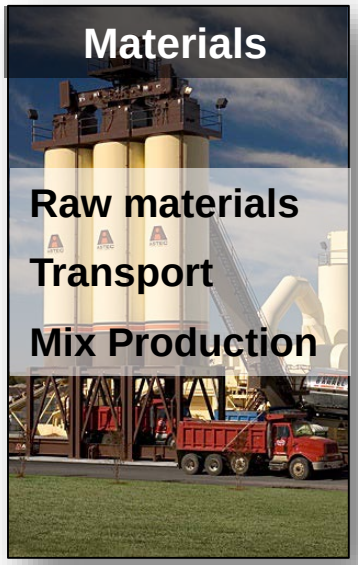
What is LCA?

- A method for characterizing and quantifying environmental sustainability of a product or service
- Applies a "cradle-to-grave" perspective when analyzing products or systems
- LCA methodology follows general purpose ISO 14000 series of standards for all products and services
- First use of LCA is a study sponsored by the *Coca Cola Company* in 1969
  - Business decision between reusable or disposable

Pavement LCA

- **Accounting for inputs and outputs throughout pavement life-cycle**

Fuel | Electricity | Resources

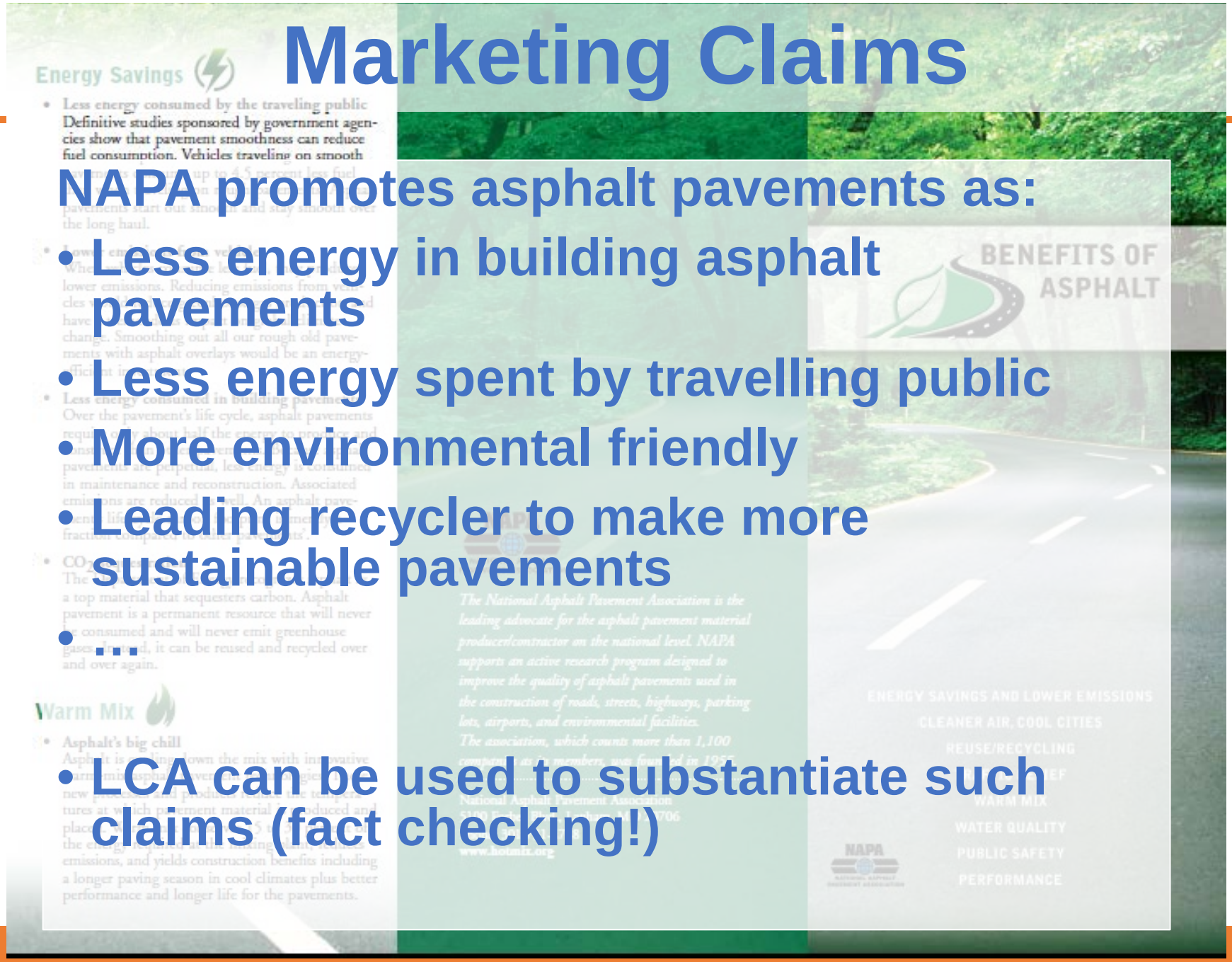


Emissions to air | Emissions to water | Emissions to soil

What Can I Use LCA For?

- **Accounting**
  - Provide numbers for reporting requirements
    Example: What GHG emissions are attributable to DOT infrastructure projects this year?
- **Decision support**
  - Provide information that can influence a decision
    Example: Which pavement alternative uses the least energy? Which mix design has least impact while providing same function in the design?
- **Process improvement**
  - Provide feedback to improve a process
    Example: How can we reduce the GHG footprint of an asphalt mix? Transportation, plant energy use, or somewhere else???

Marketing Claims



NAPA promotes asphalt pavements as:

- Less energy in building asphalt pavements
- Less energy spent by travelling public
- More environmental friendly
- Leading recycler to make more sustainable pavements
- …

- LCA can be used to substantiate such claims (fact checking!)

LCA in Decision Making

- Paper or plastic bags?
- Refillable or disposable?
- Electric vs. fuel driven cars
- Biomass vs. petroleum products?
- Cars vs. transit buses?
- How about pavements?
  - Design and type selection
  - Maintenance and rehabilitation schedule (when to do and what to do to optimize impact)
  - Material selection
  - …

Future of LCAs

- **Environmental Product Declarations (EPDs) are underway for asphalt and concrete paving materials**

Environmental Facts

Declared unit: 1 ton of HMA produced in a counter-flow drum plant

Primary Energy Demand [GJ]	354
Global Warming Potential [kg-CO2-eq]	19.5
Acidification Potential [kg-SO2-eq]	0.16
Eutrophication Potential [kg N-eq]	0.0026
Smog Potential [kg 03-eq]	0.51
Ozone Depletion [kg CFC-11-eq]	1.6×10^{-7}

Boundaries: Cradle-to-gate

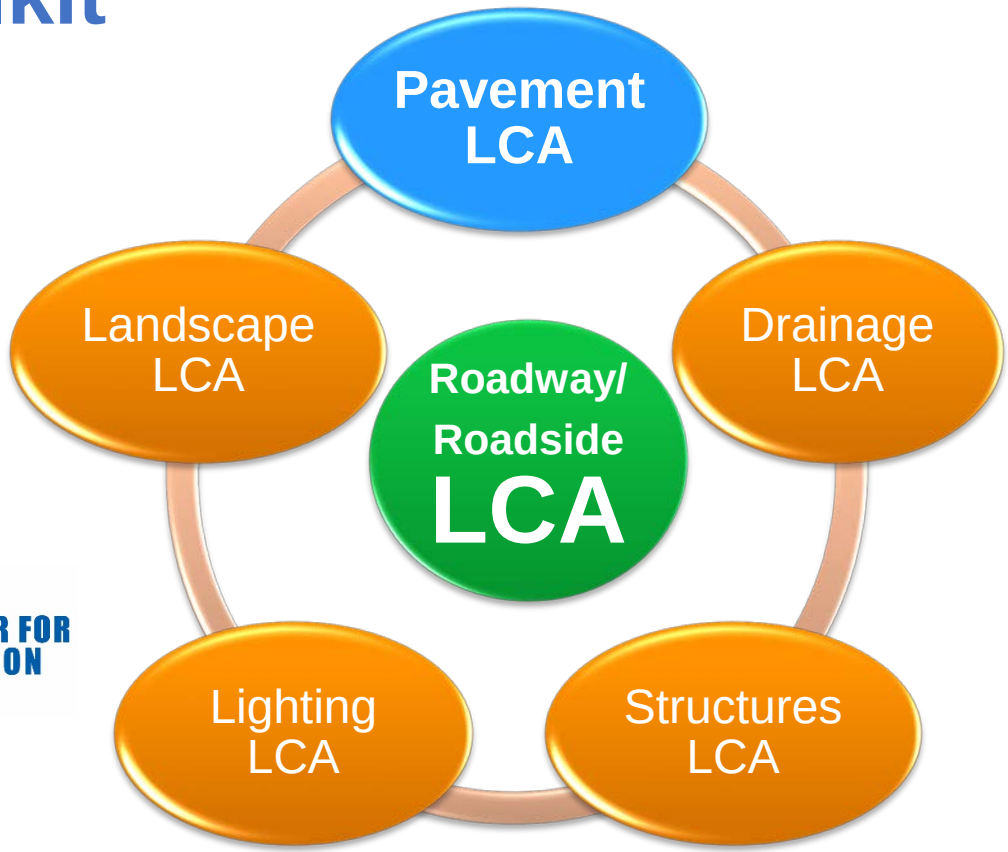
Company: XYZ asphalt

Recycled Content: 20% by weight of mix

Impact Approach: TRACI 2.1

Illinois Tollway LCA Tool

- The Pavement LCA is **one of five LCA modules** in the Tollway's Roadway/ Roadside LCA Toolkit



Illinois Tollway

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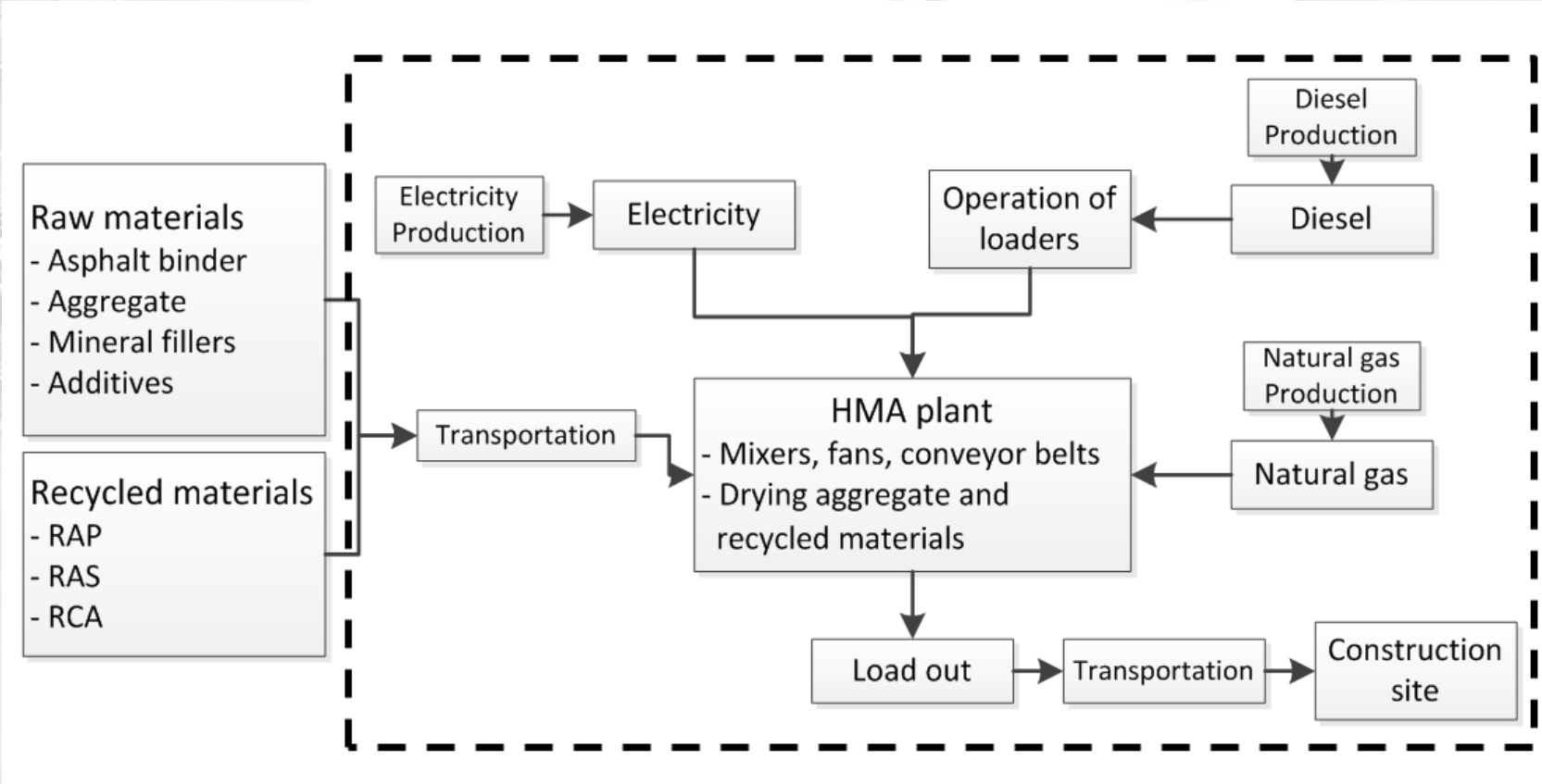
Strategies for Improving Sustainability

1. Increase material performance and time between future maintenance and rehabilitation treatments
   - Mix design and material selection
   - Construction quality
2. Reduce % of virgin asphalt binder & aggregate, polymer
   - Use more RAP, recycled tire rubber, consider RAS
   - Only use additional additives where performance increase warrants additional environmental impact
3. Reduce materials transportation
   - Use locally available but lower quality aggregates
   - Use in-place recycling
4. Improve efficiency of plant operations

!! Always check pavement performance to make sure it is not compromised !!

Where Does the Energy Go?

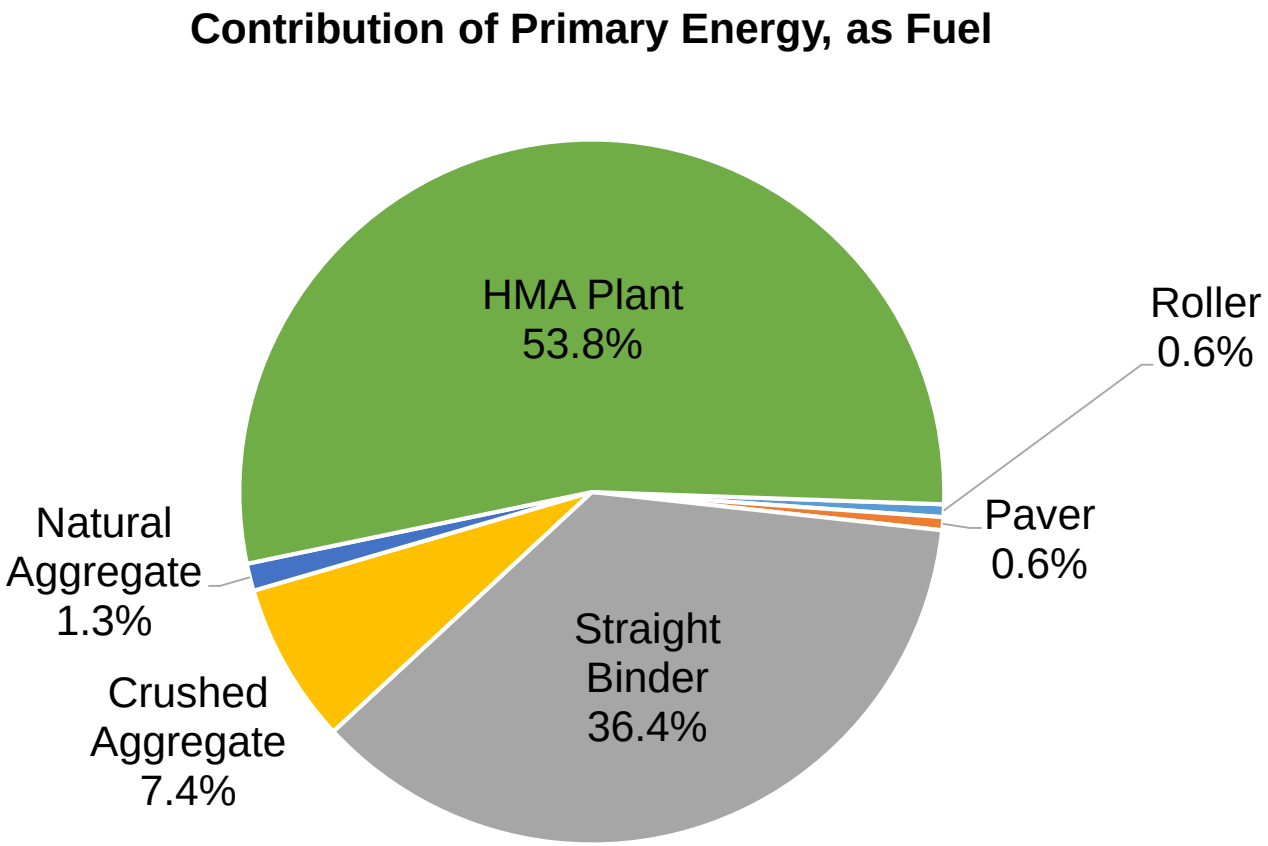
- First, we define a system boundary to calculate all inputs and outputs



Yang, R., Kang, S., Ozer, H. and Al-Qadi, I.L., 2015. Environmental and economic analyses of recycled asphalt concrete mixtures based on material production and potential performance. *Resources, Conservation and Recycling*, *104*, pp.141-151.

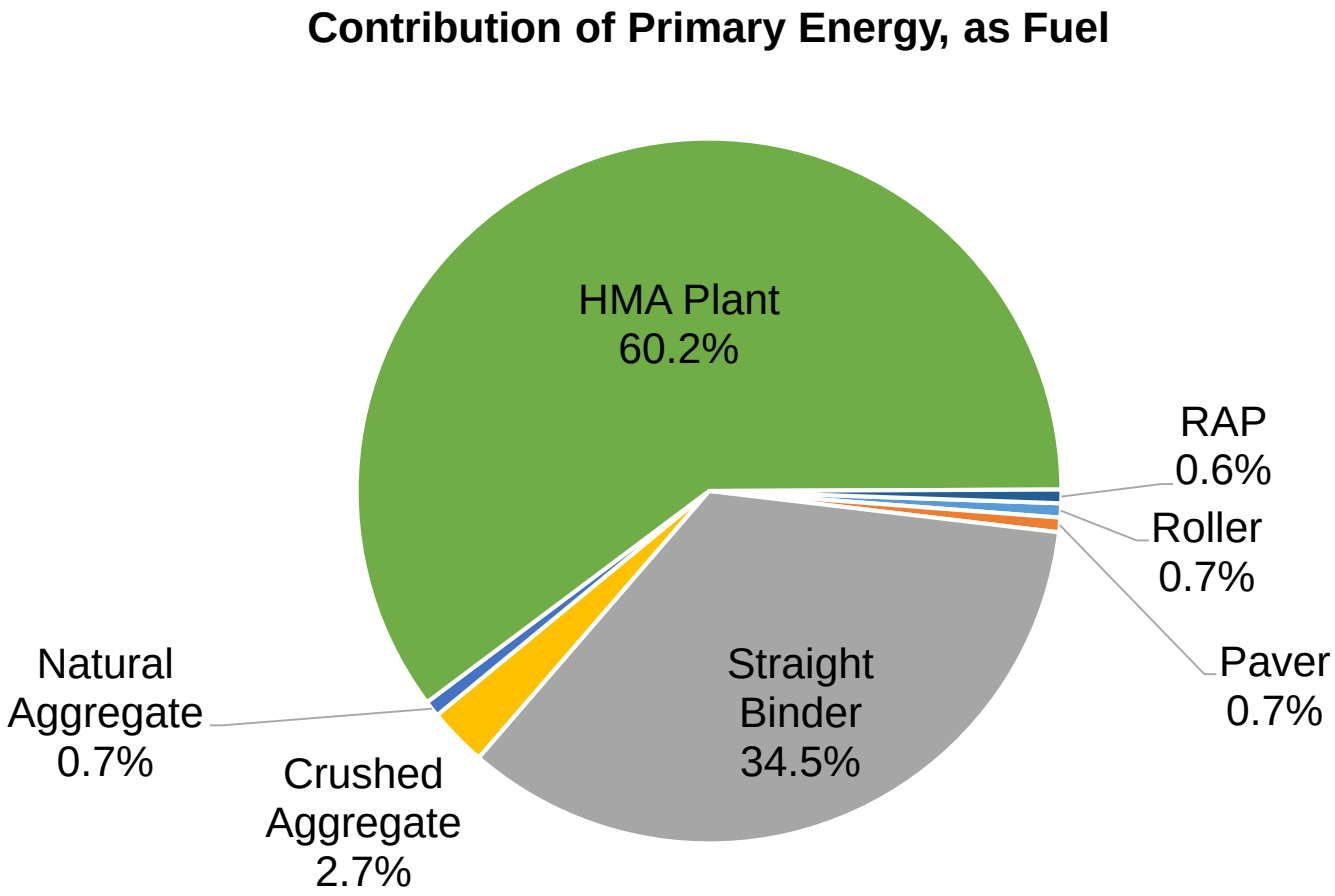
HMA Primary Energy (as fuel) Breakdown

- **Virgin HMA Surface Mix**



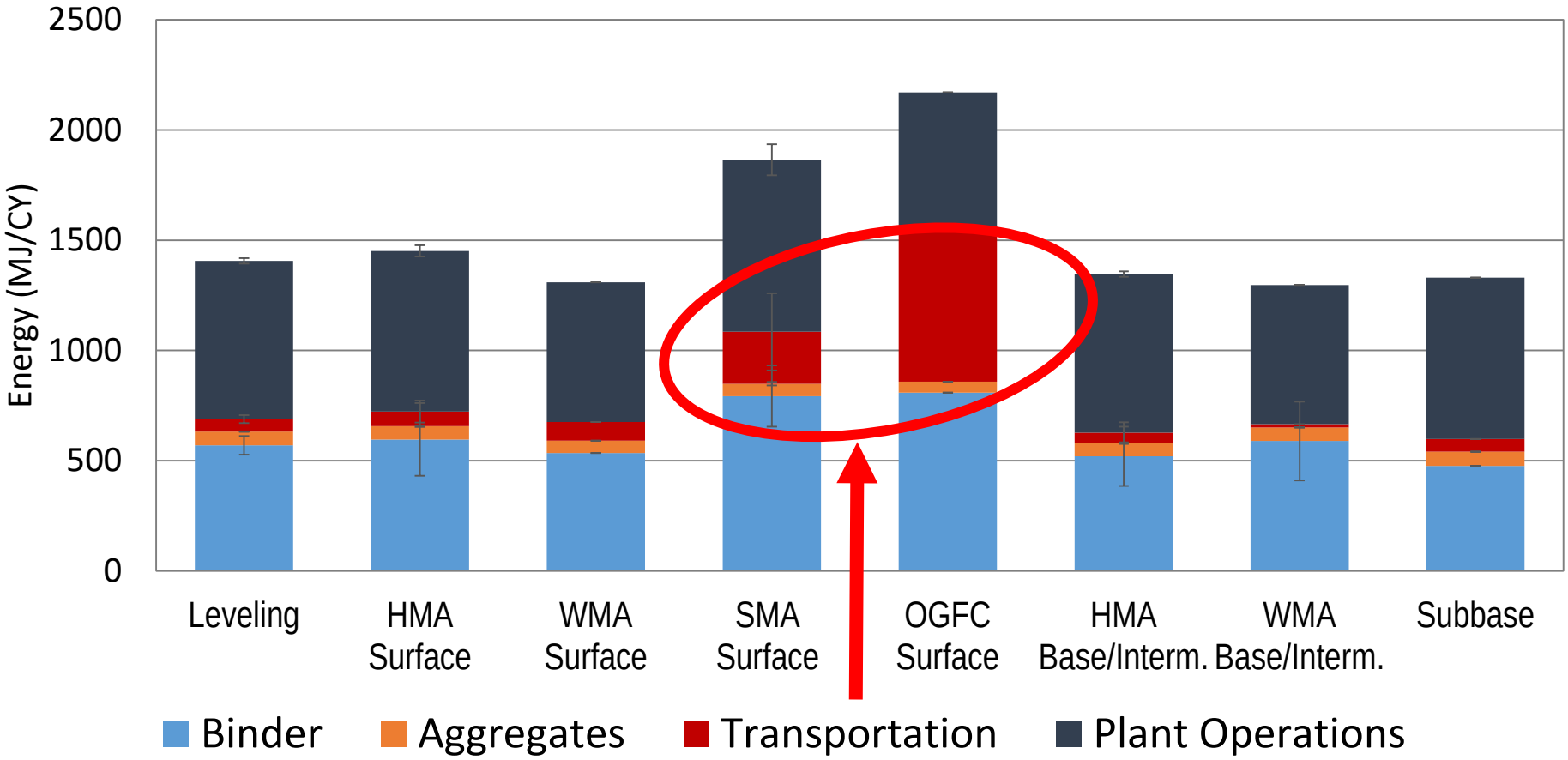
HMA Primary Energy (as fuel) Breakdown

- 17% Recycled HMA Surface Mix



Different Types of Mixes

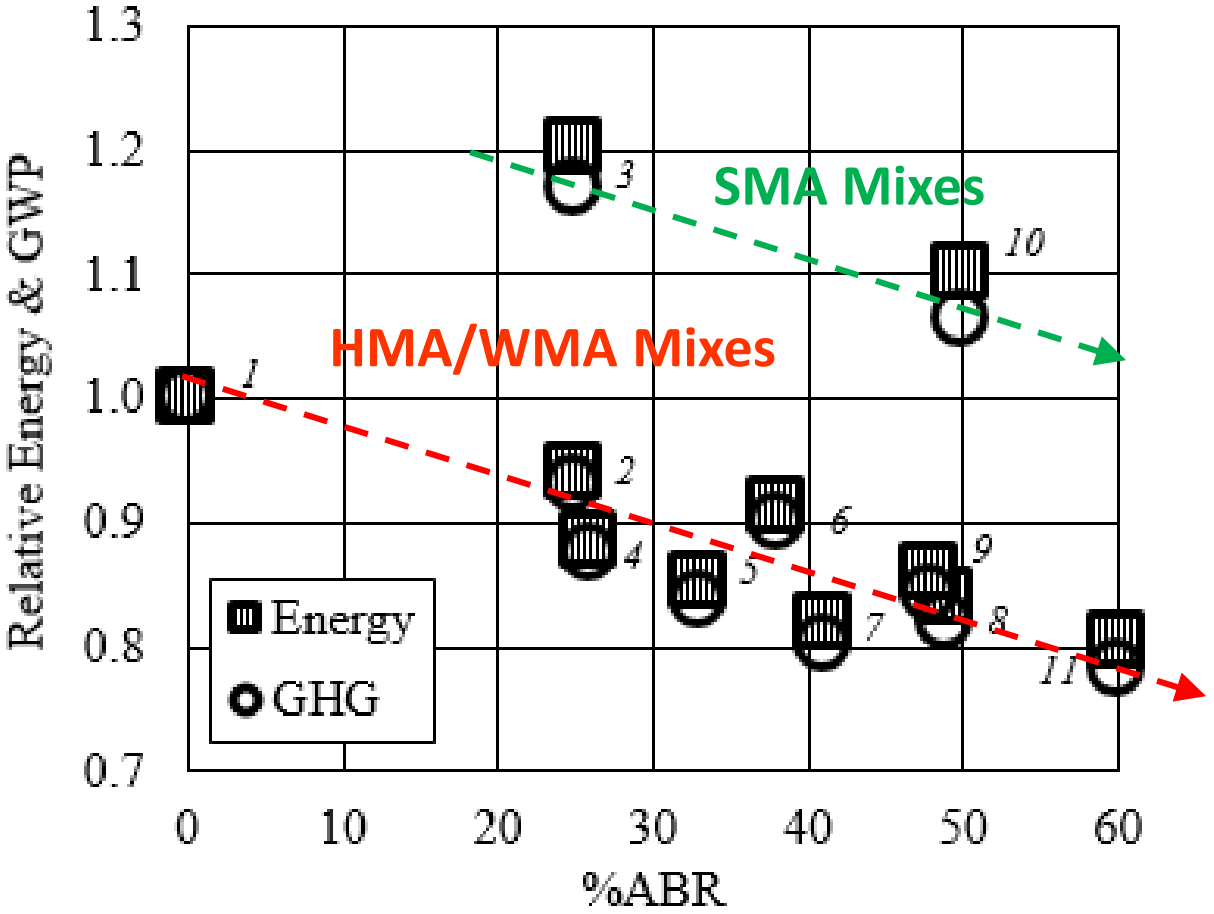
Energy Consumption from Producing and Mixing



Yang et al. (2015). Quantifying Sustainable Strategies for the Construction of Highway Pavements, TRB

RAP and Environment

- Clear reduction in energy and GWP when using recycled materials for replacing virgin binder with recycled binder
- SMAs have generally higher energy and GWP



Common mixtures used in Illinois having various combinations of RAP and RAS that result in different asphalt binder replacement (ABR) levels

Virgin vs. RAP/RAS

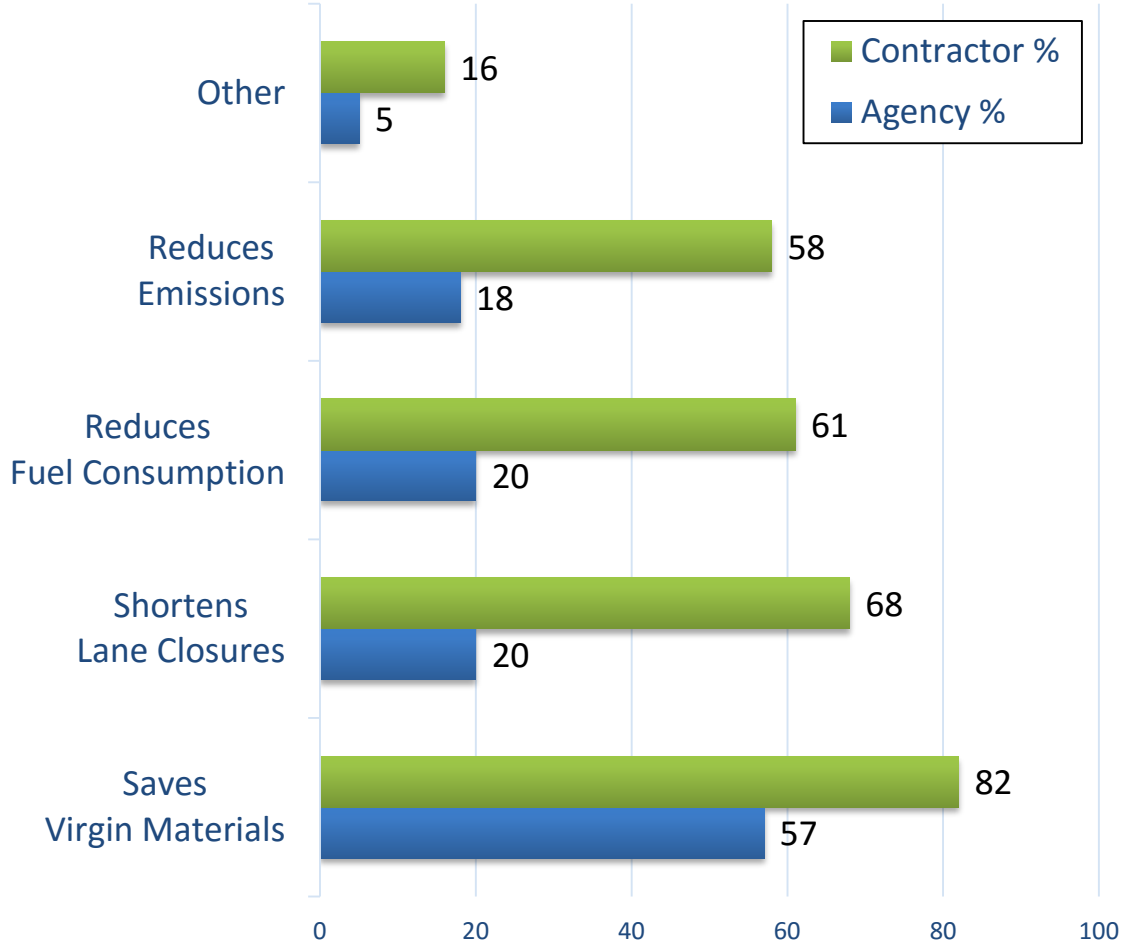
- The following questions need to be answered:
  - Can equivalent or better performance achieved?
  - What is the transportation distance?
  - Does RAP undermine future recyclability?
  - Can target volumetrics be achieved in the plant and field?
  - Are there any specifications limiting its use?
- LCA provides a systematic platform to make a comparative assessment and answer such questions

In-Place Recycling

- Three commonly used techniques are:
  - Hot in-place recycling (HIR)
  - Cold in-place recycling (CIR)
  - Full depth reclamation (FDR)

State & Contractor Perspectives

Environmental Benefits from using in-place recycling



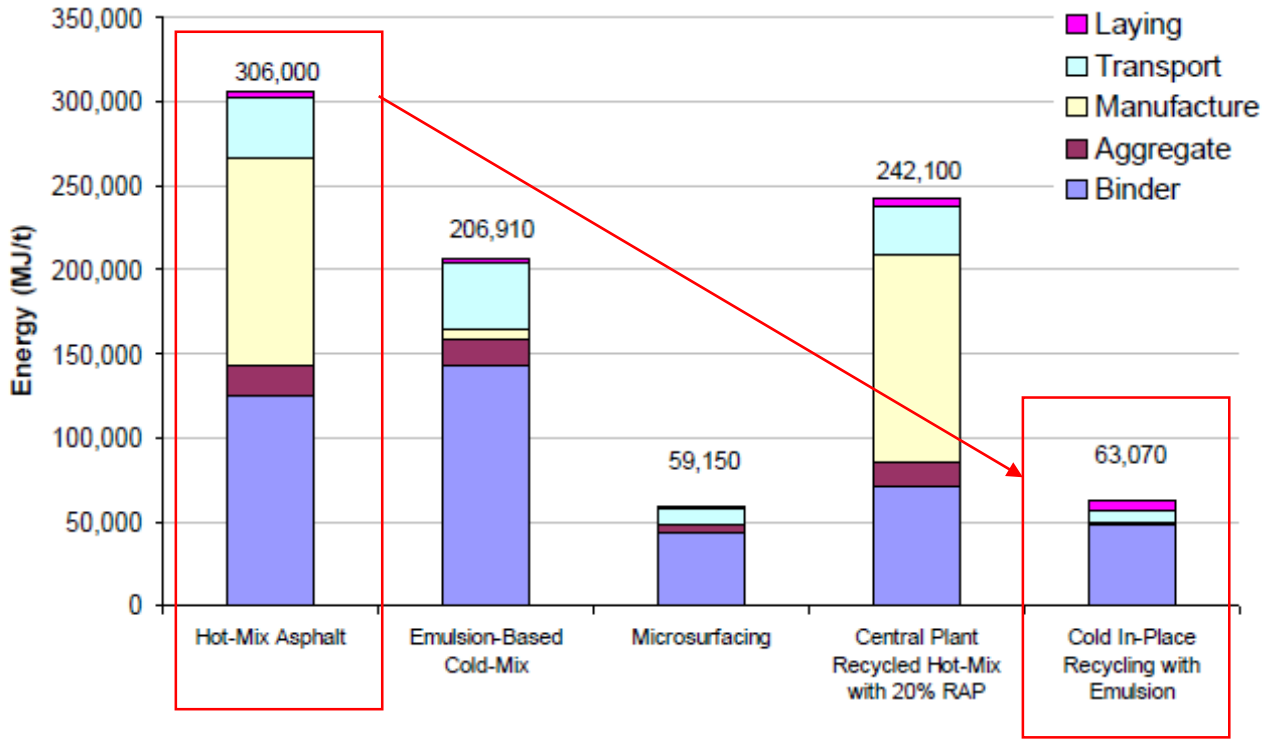
- **Overall perception is positive**
- **Use is limited to less than 50 lane-miles a year**

Stroup-Gardiner (2011). Recycling and Reclamation of Asphalt Pavements Using In-Place Methods.

Sustainability Impacts

- Literature is full of studies reporting significant reduction in energy and emissions with in-place techniques

Energy Used per Lane-Kilometer of Material Laid Down



Adapted from '*The Environmental Road of the Future, Life Cycle Analysis*' by Chappat, M. and Julian Bilal, Colas Group, 2003.

Sustainability Impacts

- Very context sensitive
  - CIR treatment life reported in the literature: 6 to 15 years (Peshkin et al. 2011)
- Avoided hauling and its impacts
- Traffic closures and resulting delays
- Surface treatment type
- Availability of specialized contractor and mobilization distances
- Additive selection (emulsion vs. cement)
- Depth of recycling
- …

Ongoing FHWA Study

- FHWA study is underway to develop a "Life-Cycle Methodology and Tool for Energy Use by In-Place Pavement Recycle Techniques"
- University of Illinois, UCDavis, and Rutgers are partnering
- The life-cycle tool will make comparative assessment considering:
  - Regional characteristics
  - Life-cycle methodology
  - Realistic contractor data collected across the US
  - Agency surveys
  - User friendly tool that can be used by agencies and contractors

Concluding Remarks

- Sustainability is a system characteristics and goals cannot be achieved alone by one contractor, one agency, or one industry
- There are tools and sufficient number of strategies for asphalt pavements to make a difference
- Sustainability goals can provide opportunities to both agencies and industry
- Sustainability can help contractors and producers to enhance their product portfolio (WMA example)