



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

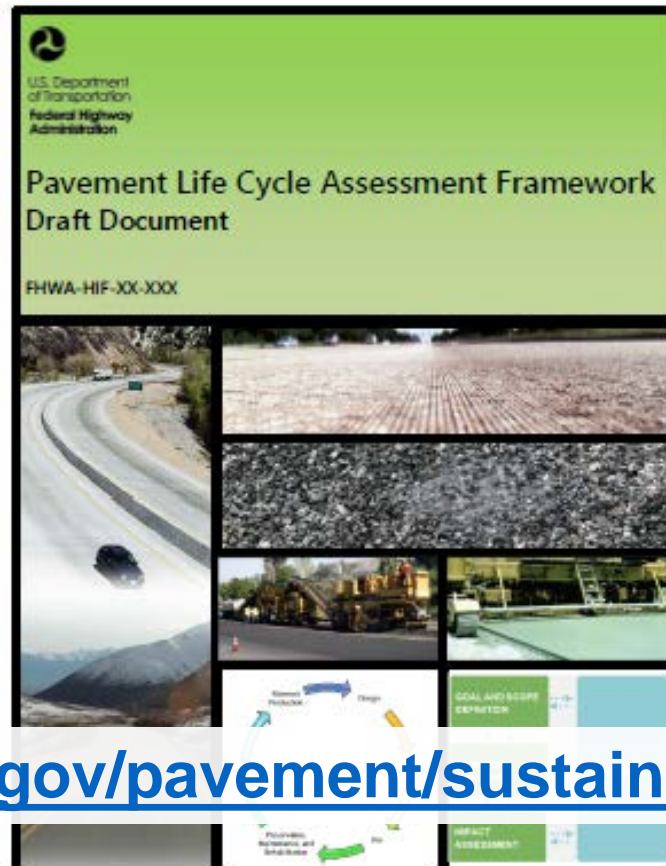
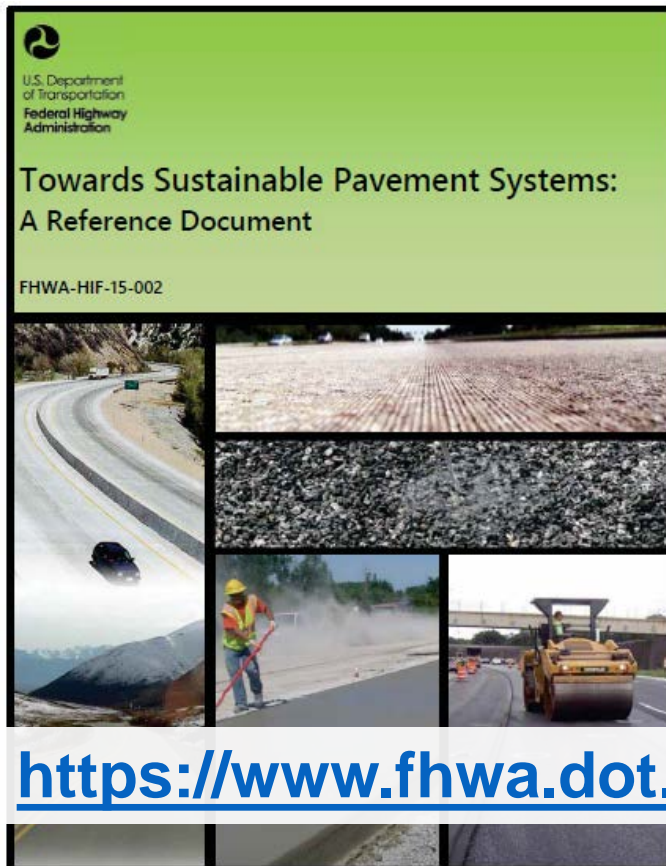
Signed Secretary Anthony R. Foxx, June 2014



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

Materials

Construction

Maintenance

Use

End-of-Life

Raw materials
Transport
Mix Production

Transport
Equipment
Placement
Traffic Delay

Repairs
Rehabilitation

Pavement deterioration
Rolling resistance
Albedo
Lighting

Transport
Landfill
Recycling

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

Energy Savings

- Less energy consumed by the traveling public

Definitive studies sponsored by government agencies show that pavement smoothness can reduce fuel consumption. Vehicles traveling on smooth pavements start out smooth and stay smooth over the long haul.

When you smooth out a road, you reduce the lower emissions. Reducing emissions from vehicles is a key strategy for reducing global climate change. Smoothing out all our rough old pavements with asphalt overlays would be an energy-efficient investment.

Over the pavement's life cycle, asphalt pavements require about half the energy to construct and maintain than concrete pavements. Because asphalt pavements are perpetual, less energy is consumed in maintenance and reconstruction. Associated emissions are reduced, as well. An asphalt pavement's life cycle emissions are 50 percent lower than those of concrete pavements.

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Asphalt is a top material that sequesters carbon. Asphalt pavement is a permanent resource that will never be consumed and will never emit greenhouse gases. Instead, it can be reused and recycled over and over again.

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Warm Mix

- Asphalt's big chill
- Asphalt is cooling down the mix with innovative warm mix technologies. These technologies use new processes and products reduce the temperatures at which pavement materials are produced and placed. This reduces the energy needed to produce emissions, and yields construction benefits including a longer paving season in cool climates plus better performance and longer life for the pavements.

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

The National Asphalt Pavement Association is the leading advocate for the asphalt pavement material producer/contractor on the national level. NAPA supports an active research program designed to improve the quality of asphalt pavements used in the construction of roads, streets, highways, parking lots, airports, and environmental facilities.

The association, which counts more than 1,100 companies as members, was founded in 1957.
National Asphalt Pavement Association
5140 North Elm Street, Champaign, IL 61706
www.natap.org



- ENERGY SAVINGS AND LOWER EMISSIONS
- CLEANER AIR, COOL CITIES
- REUSE/RECYCLING
- DEF WARM MIX
- WATER QUALITY
- PUBLIC SAFETY
- PERFORMANCE



• 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 O3-eq]	0.51
Ozone Depletion [kg CFC-11-eq]	1.6x10 ⁻⁷

Boundaries: Cradle-to-gate

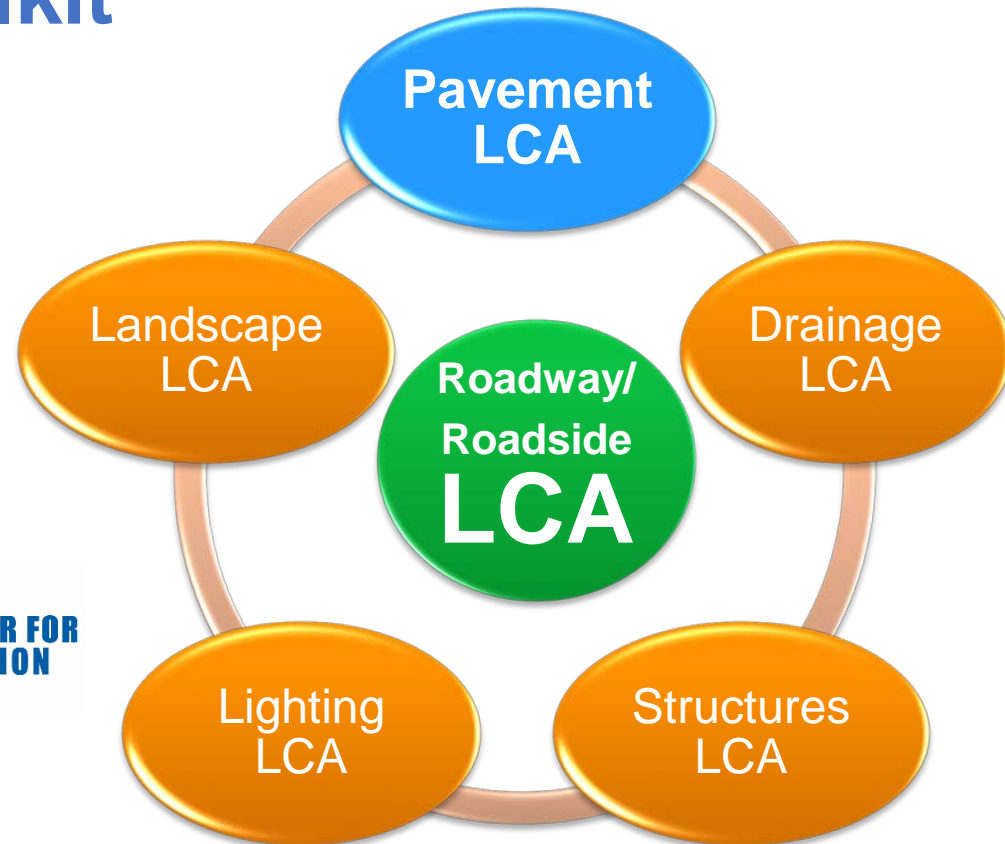
Company: XYZ asphalt

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





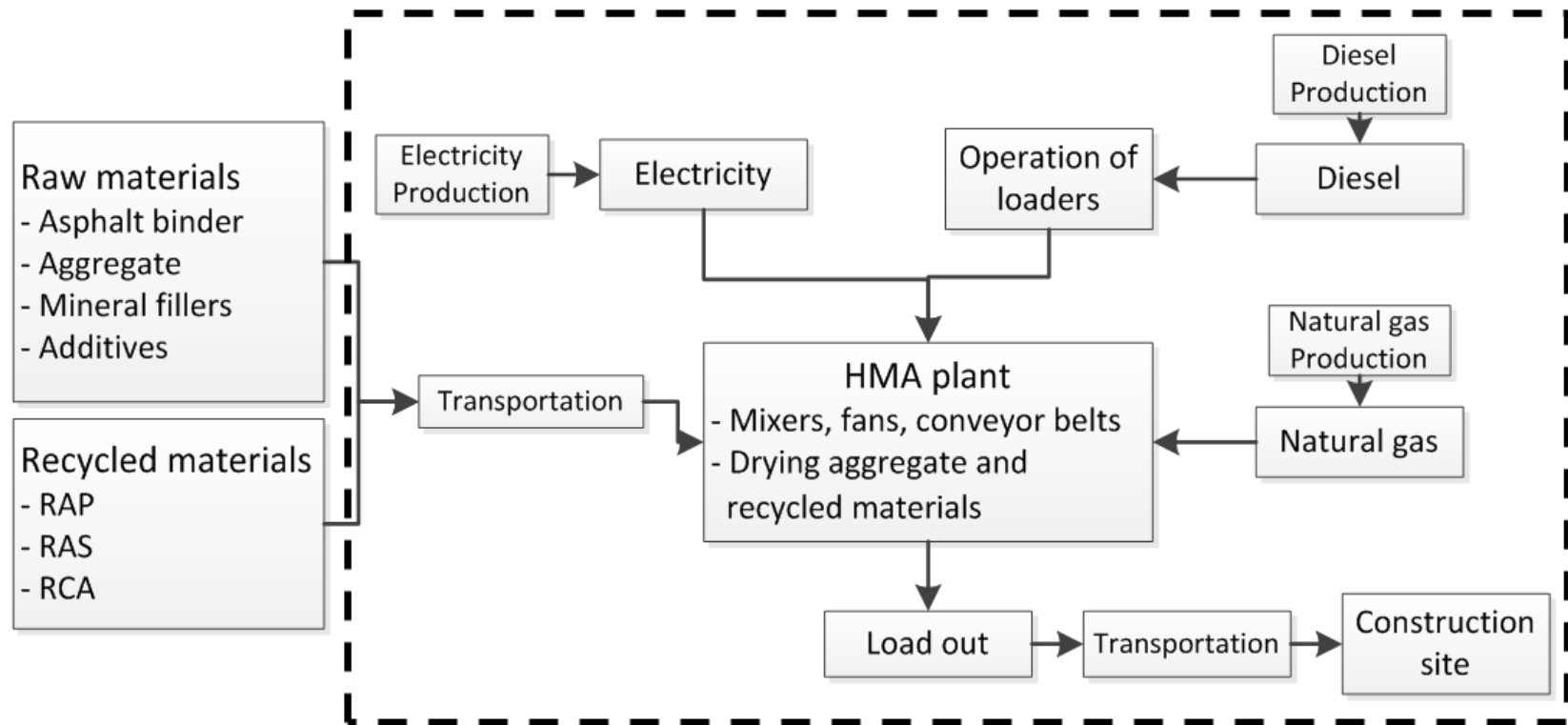
Strategies for Improving Sustainability

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 material 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



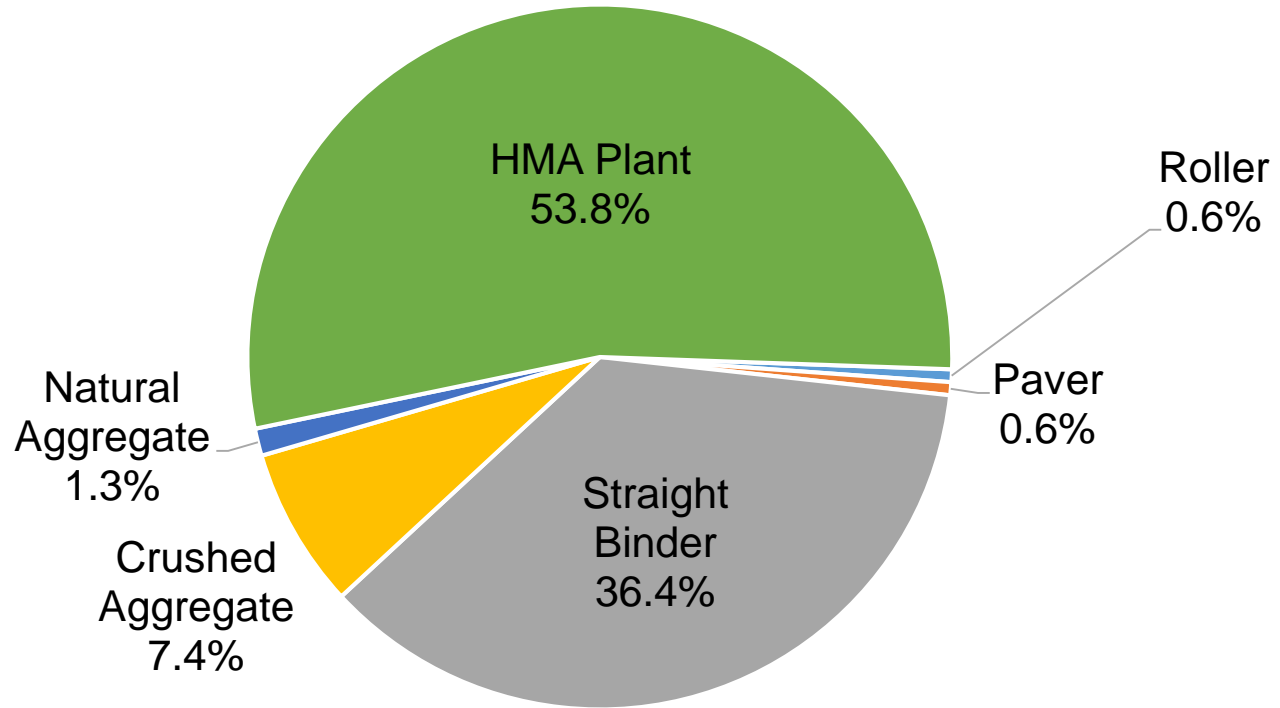
Yang, R., Kang, S., Ozer, H. and Al-Qadi, I.L., 2015. Environmental and economic analyses of recycled asphalt concrete mixtures based on material production and potential performance. *Resources, Conservation and Recycling*, 104, pp.141-151.



HMA Primary Energy (as fuel) Breakdown

- **Virgin HMA Surface Mix**

Contribution of Primary Energy, as Fuel

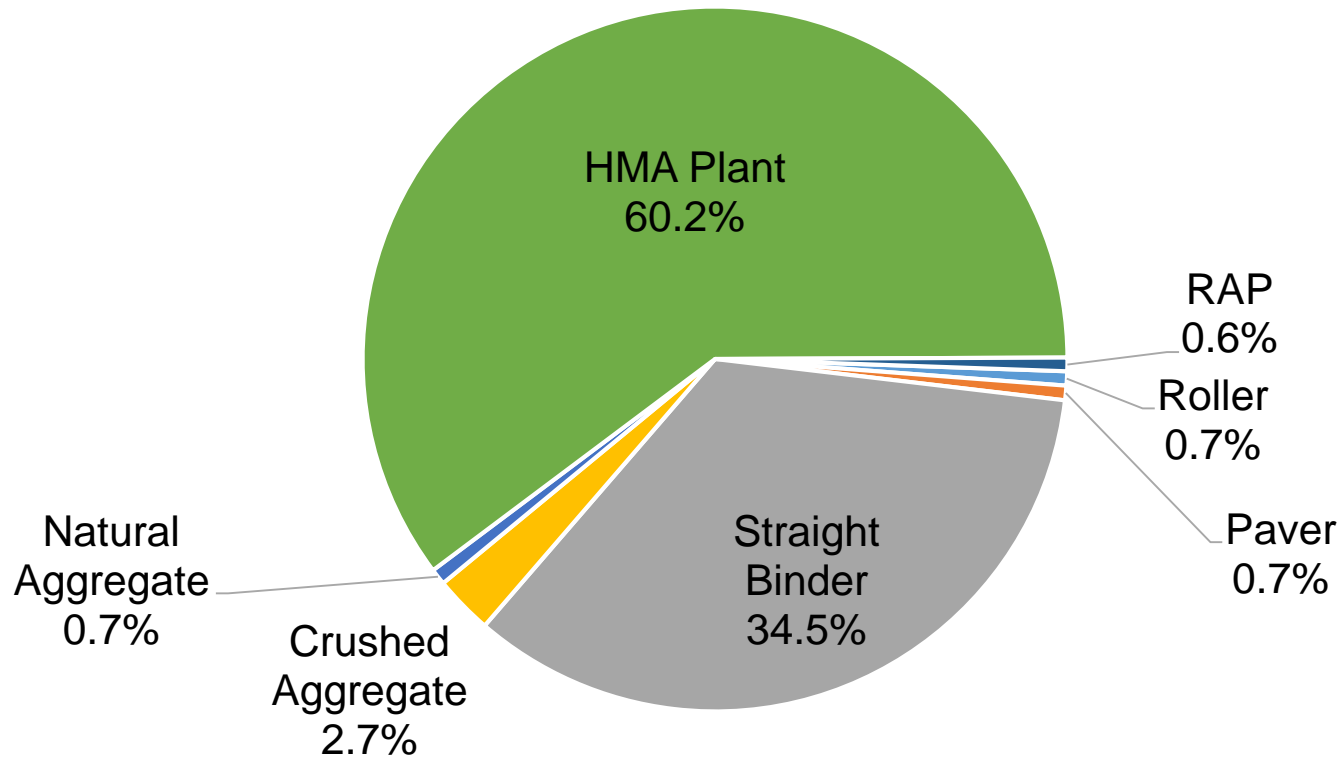




HMA Primary Energy (as fuel) Breakdown

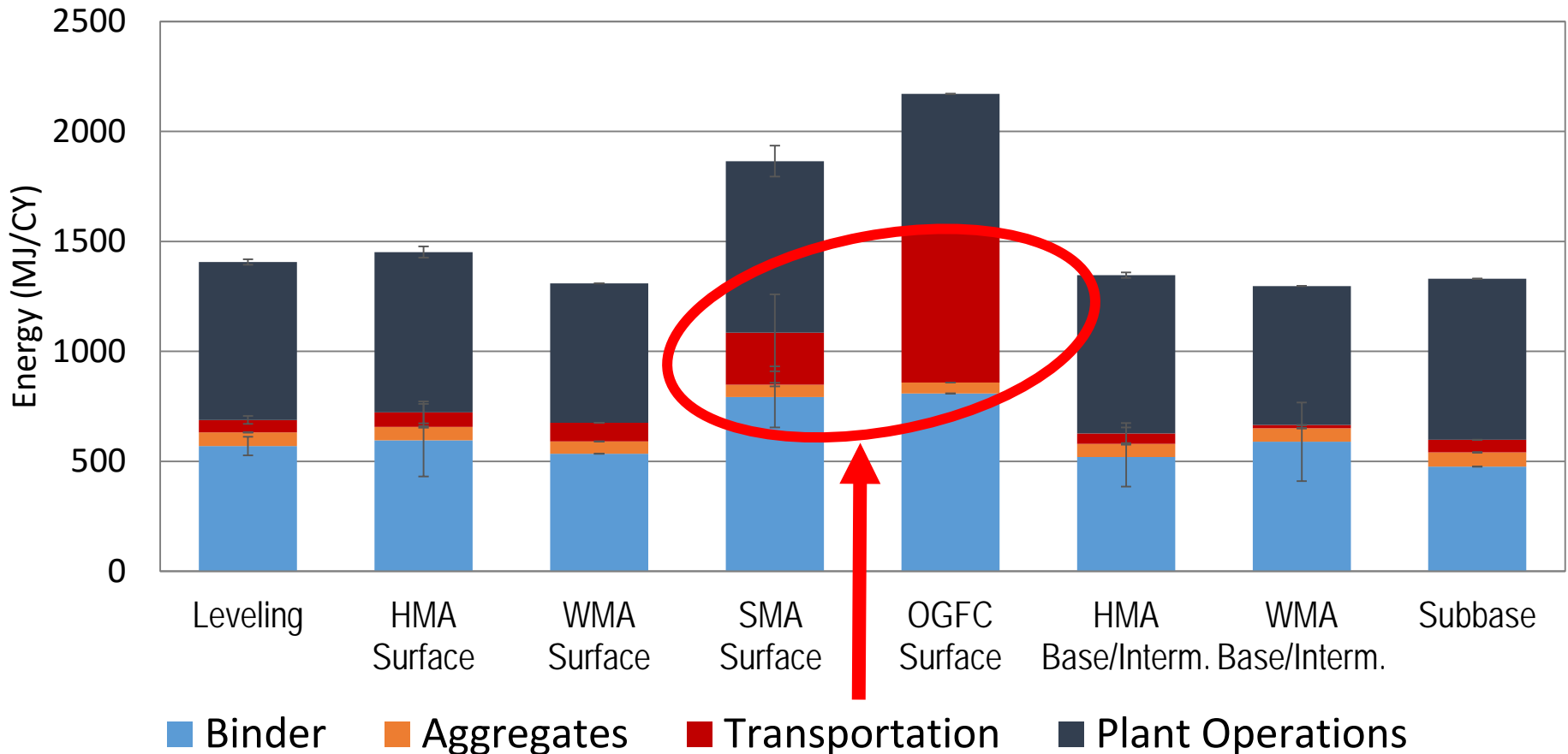
- 17% Recycled HMA Surface Mix

Contribution of Primary Energy, as Fuel



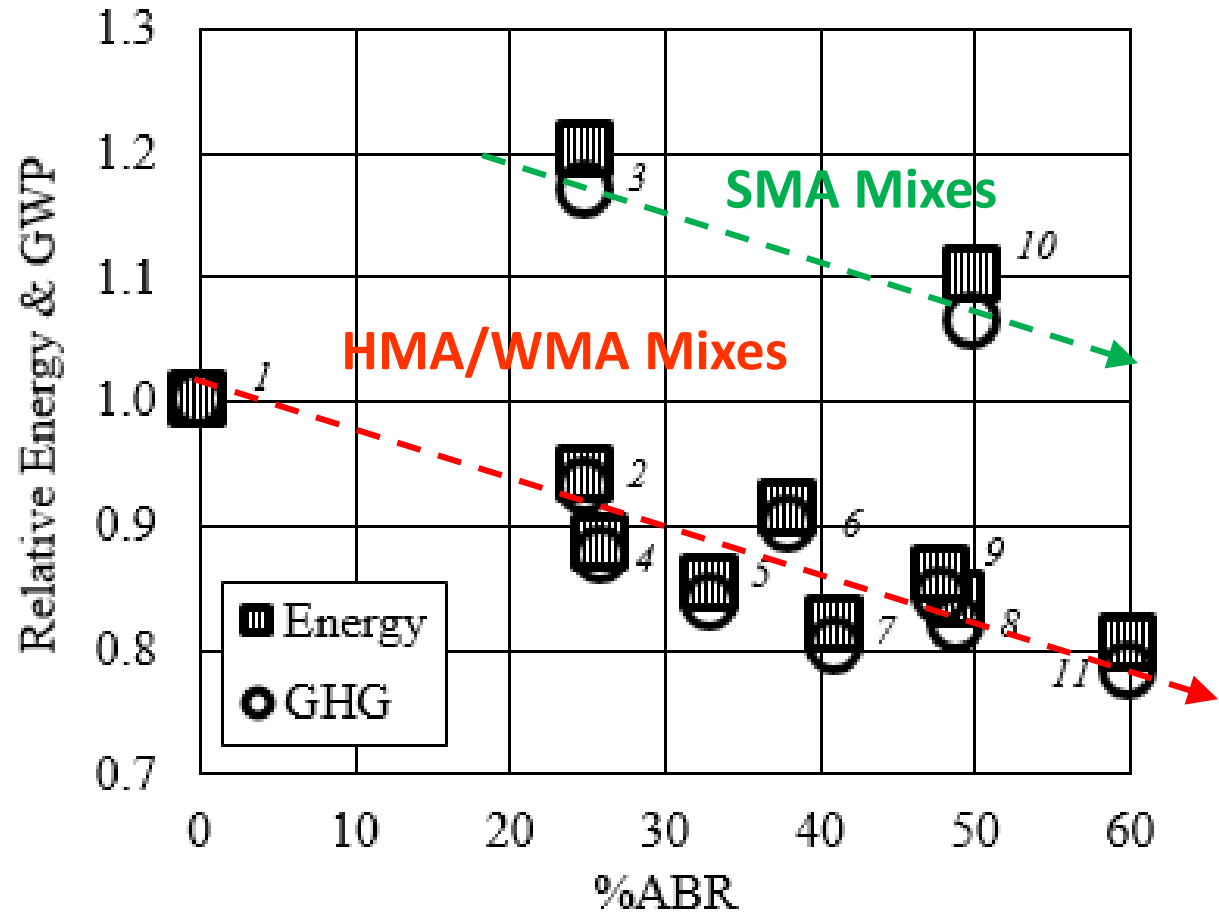
Different Types of Mixes

Energy Consumption from Producing and Mixing



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**

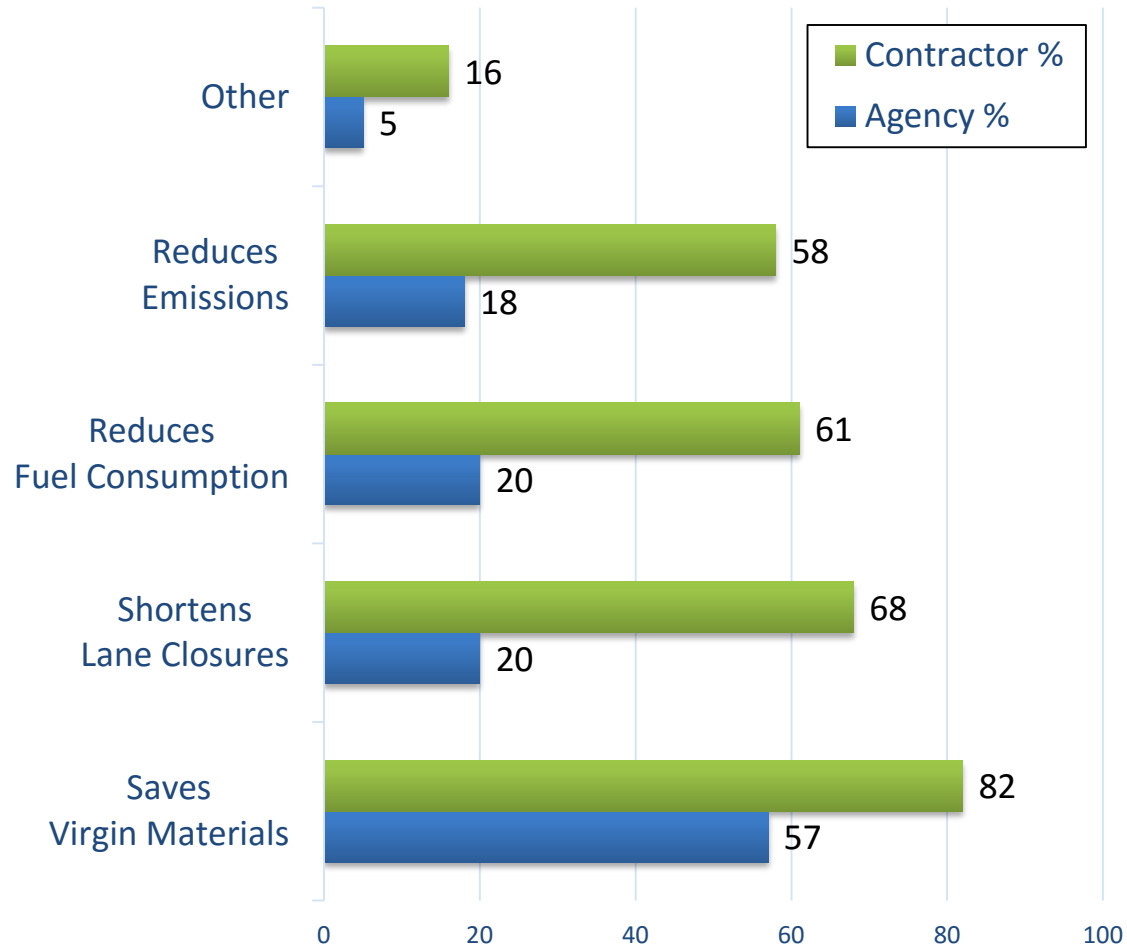
In-Place Recycling

- **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

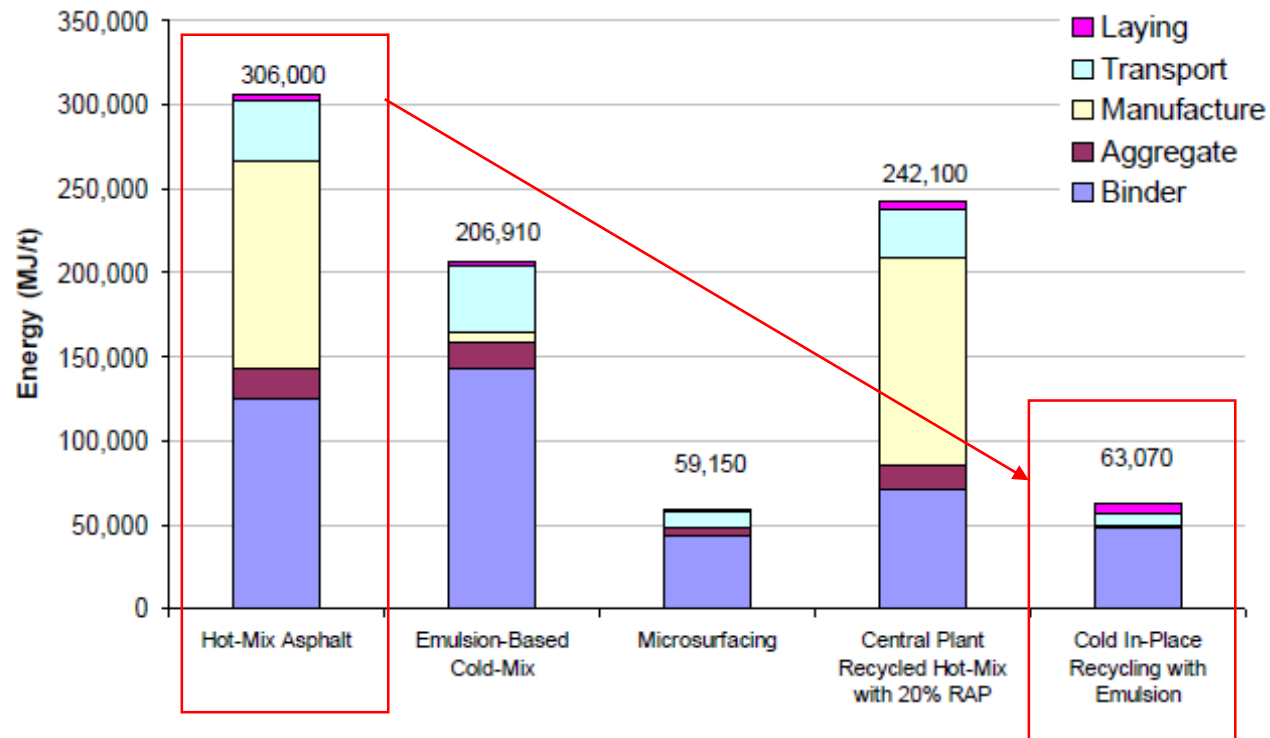


- Overall perception is positive
- Use is limited to less than 50 lane-miles a year

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, UC Davis, 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)**