Greening the Blacktop

ASPHALT: the environmentally sustainable pavement

Greening the Blacktop
ASPHALT: the environmentally sustainable pavement

- Background information
- Stormwater management / porous pavement
- UHI and reflective asphalt pavements
- USGBC LEED
- Recycled materials / RAP
- Env. Impacts and Carbon Footprints
- Warm Mix Asphalt
. . . what is it?

environmental sustainability
What is LEED?
The LEED Green Building Rating System is the national benchmark for high performance green buildings. Learn More.

What's New

Former President Bill Clinton to Keynote Opening Plenary of Greenbuild

Clinton's keynote will kick off what is expected to be the largest Greenbuild ever. Read More.

LEED for High Performance Operations Second Public Comment Period Now Open

Please weigh in on changes made since the first public comment period. Read More.

Call for Nominations for the 2007 Chapter Awards

Awards recognize outstanding chapter achievements in Advocacy, Education, Research, LEED, USGBC as a Community, and Organizational Excellence. Read More.

USGBC featured in THE 11th HOUR
Asphalt is the sustainable material for constructing pavements.

From the production of the paving material, to the placement of the pavement on the road, to rehabilitation, through recycling, asphalt pavements minimize impact on the environment. Low consumption of energy for production and construction.
Energy and Recycling

Less energy consumed in building pavements
Asphalt pavements require about 20 percent less energy to produce and construct than other pavements.¹

Less energy consumed by the traveling public
Congestion leads to unnecessary consumption of fuel and production of emissions. Reducing congestion by constructing asphalt pavements just makes sense. Asphalt pavements are faster to construct and rehabilitate. And, a new or newly rehabilitated asphalt pavement can be opened to traffic as soon as it has been compacted and cooled. There is no question of waiting for days or weeks for the material to cure.

America’s leading recycler
According to an EPA/FHWA study,² the asphalt industry recycles more than 70 million tons of its own product every year, making it America’s number one recycler. Asphalt recycling saves taxpayers about $1.8 billion a year.

Performance

The road doesn’t wear out
Asphalt is the Perpetual Pavement. When appropriately designed and constructed, the road itself doesn’t.
urban development
stormwater management
stormwater management

RAINFALL 45”/YR

REDUCED INFILTRATION THROUGH REGRADED AND COMPACTED SOILS IN GRASSES

EVAPORATIVE LOSS FROM IMPERVIOUS SURFACES

43” RUNOFF FROM IMPERVIOUS COVER

0” OF INFILTRATION UNDER IMPERVIOUS SURFACES

REDUCTION IN BASE FLOW BY 15”/YR UNDER IMPERVIOUS SURFACES
Porous Pavement with Recharge Bed

River Jacks Open Into Recharge Bed

Porous Asphalt

Stone Bed w/ 40% Void Space For Storage/Recharge

stormwater management
Standard Pavement

Porous Pavement

Univ. NC: add’l parking lot constructed ca. 2002

stormwater management
WHAT IS A GREEN STREET?

The streets at Pringle Creek Community are part of an integrated water infiltration system that captures, absorbs and filters stormwater instead of sending it downstream in pipes. If the first one inch of every rainfall is captured and absorbed, 90% of rainwater is prevented from entering stormwater pipes.

Read More >

View Street Diagram >

Taxes on impervious residential surfaces - Iowa... and more states to come

porous streets!!
WHAT IS A GREEN STREET?

- **Surface Swale**: Gravel seam next to roadway, 8 inches of crushed rock on top of 10 inches of crushed drain rock.
- **Filter Fabric**: Along perimeter between rock and subgrade.
- **Impervious Sidewalks**: 4 inch porous concrete on top of recycled crushed concrete or native subgrade.
- **Eco-Grass Planting Strips**: Native grasses, plants and trees between sidewalk and street are part of drainage and filtration system.

Porous Street Section:
Benefits of Porous Pavement

**Economic**
- Reduces/Eliminates the land space consumed by conventional detention facilities
- Helps prevent excessive flooding and minimizes need for control measures

**Aesthetic**
- Eliminates the need for unsightly detention basins
- Preserves areas such as woods/open space

**Environmental**
- Limits peak stormwater discharge and improves water quality of any runoff
- Reduces amount of impervious surfaces
Dense-graded asphalt pavements were historically the standard for roadways
- Provides structure, strength, and smoothness
- Smoothness can cause water overspray

Open-graded Friction Courses (OGFC) developed to minimize overspray
- Developed in the late 1940s (airports)
- Pavement contains greater air voids
- Thin OGFC pavement above dense-graded mat

OGFC Highly successful in minimizing accidents
- Calif-DOT identified a 50% decrease in deaths and 20% decrease in accidents after Hwy re-paved using OGFC
- Other state statistics similar
Spray Reduction: OGFC on Freeway

safer pavements
Vehicles on highways generate a significant amount of noise.

Noise from the tire/pavement interface accounts for over 75% of the vehicle noise.

Sound-walls are expensive and are only somewhat effective if placed in the line-of-sight:
- They reduce noise minimally and only over certain distances from the roadway.
- Sound-walls can increase UHI effects because they decrease air movement across pavement surface.

Traffic Noise can be significantly reduced using Open-Graded Friction Courses (OGFC).
Noise Reduction: AR-OGFC on Highway

SR 202W
11/7/03 106 dB(A)

quieter pavements
Urban Heat Islands
Pavement Temperatures vs. Albedos

- San Ramon, 8/7/98
- Berkeley, 9/13/96

myth or reality?
Location: University Dr., Tempe, AZ
Time: 2:30pm, May 15, 2007

Albedo = .192
Surf. Temp = 131, 131.5, 130 (°F)
Age = >5 years
Traffic = light foot, cart and bicycle traffic

Albedo = .090
Surf. Temp = 129.9, 130.2, 128.4 (°F)
Age = >5 years
Traffic = constant traffic

Albedo = .036
Surf. Temp = 146.8, 143.3, 147.4 (°F)
Age = 3 days
Traffic = no traffic

reflectivity & temperatures

[Image of road with infrared thermal imaging data]
Location: University Dr., Tempe, AZ
Time: 2:30pm, May 15, 2007

Reflectivity & temperatures

Albedo = 0.192
Surf. Temp = 131, 131.5, 130 (°F)
Age = >5 years
Traffic = light foot, cart and bicycle traffic

Albedo = 0.090
Surf. Temp = 129.9, 130.2, 128.4 (°F)
Age = >5 years
Traffic = constant traffic

Albedo = 0.036
Surf. Temp = 146.8, 143.3, 147.4 (°F)
Age = 3 days
Traffic = no traffic
Los Angeles: Simulate change of all pavement albedos (in < 20 years of normal maintenance)

**Input:**
- Albedo change = 0.25
- Pavement area = 1,250 km²
- Urban area = 10,000 km²

Normal LA weather

**Result:**
- Decrease in air temperature ≈ 0.6°C (1°F)
cooler pavements
cooler pavements
cooler pavements
Below grade w/ sound walls

¾ inch asphalt-based OGFC over dense pvmt

Airport: 23-inch thick pvmt

Interstate w/ PCC

Highway w/ PCC

Above grade w/ landscape

Below grade w/ sound walls

cooler pavements
Cool Pavements

Denotes link to glossary definition

There is no official standard or labeling process at this early stage.

While studies show that pavements can have several factors. These include the impact time, and the absorption by buildings of solar energy.

There are situations, however, where cool pavements have lower surface temperature and achieve roadways with large expanses of paved surface.

Investigations of cool paving materials have demonstrated that pavements with higher solar reflectance benefit from the cooling effect because they reflect more of the sun's energy. Construction is essential in applying either asphalt or concrete.

Other factors affecting performance, cost, and the best solutions may occur where multi-layer help with storm water runoff as well as performance.
It’s NOT a black and white issue

- pavement thickness
- material capacities
- surface vs. air temperatures
- pavement air voids (OGFC) cooler
- UHI does NOT cause Global Warming
Surface Chip Seals and Coatings: using reflective / light-colored chip / paints
“Gritting”: reflective chips and aggregate

reflective pavements
Shot-Blasting: abrading surface binder
Synthetic and Colored Binders: using reflective aggregates
Synthetic / Colored Binders: using reflective / colored aggregates
Using Asphalt Pavement to Reduce UHI

- Albedo doesn’t appear to be the entire story
- The role of thickness, density, and porosity are being evaluated to understand pavement’s heat sink capacity
- Other “BMPs” have been identified to help mitigate pavement surface temperature (trees, topography)
- OGFC / porous pavements have been shown to be highly effective in reducing pavement surface temps
- Reflective HMA pavements can be produced $$$
- But . . . IMHO . . .
- Pavement design has “net zero” balance on UHI temps
- USGBC needs to understand this . . .
Leadership in Energy and Environmental Design

What is LEED®?

The Leadership in Energy and Environmental Design (LEED) Green Building Rating System™ is the nationally accepted benchmark for the design, construction, and operation of high performance green buildings. LEED gives building owners and operators the tools they need to have an immediate and measurable impact on their buildings’ performance. LEED promotes a whole-building approach to sustainability by recognizing performance in five key areas of human and environmental health: sustainable site development, water savings, energy efficiency, materials selection, and indoor environmental quality.

LEED provides a roadmap for measuring and documenting success for every building type and phase of a building lifecycle. Specific LEED programs include:

- New Commercial Construction and Major Renovation projects
- Existing Building Operations and Maintenance
  - Commercial Interiors projects
  - Core and Shell Development projects
  - Homes
  - Neighborhood Development
  - Guidelines for Multiple Buildings and On-Campus Building Projects
- LEED for Schools
- LEED for Retail
Developed by USGBC

National benchmark for design, construction, and operation of “green” buildings

5 key areas:
- Sustainable site development
- Water savings
- Energy efficiency
- Materials selection
- Indoor environmental quality

Earning LEED certification
- Must meet certain criteria → credits / certification process
- Levels based on total credits

How asphalt pavements contribute to LEED credits

Retail Certification Levels
Certified: 26-32 points
Silver: 33-38 points
Gold: 39-51 points
Platinum: 52-70 points
LEED for new construction
buildings
Distribution
by geography
as of 07/06

AK=10
HI=16
PR=1

200+
100-199
50-99
20-49
1-19
<table>
<thead>
<tr>
<th>Category</th>
<th>Possible Points</th>
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<tr>
<td>Sustainable Sites:</td>
<td>16</td>
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<tr>
<td>Water Efficiency:</td>
<td>5</td>
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<tr>
<td>Materials &amp; Resources:</td>
<td>13</td>
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<tr>
<td>Energy &amp; Atmosphere:</td>
<td>17</td>
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<tr>
<td>Indoor Environ. Quality:</td>
<td>14</td>
</tr>
<tr>
<td>Innovation &amp; Design:</td>
<td>5</td>
</tr>
</tbody>
</table>

**Retail Certification Levels**
- Certified: 26-32 points
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- Platinum: 52-70 points

**Green Building Rating System**
**LEED for Retail - New Construction and Major Renovations**
## Sustainable Sites

<table>
<thead>
<tr>
<th>Credit</th>
<th>Description</th>
<th>Points</th>
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<tbody>
<tr>
<td>1</td>
<td>Construction Activity Pollution Prevention</td>
<td>Required 5 credits</td>
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<tr>
<td>2</td>
<td>Development Density &amp; Community Connectivity</td>
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<tr>
<td>3</td>
<td>Brownfield Redevelopment</td>
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<tr>
<td>4</td>
<td>Alternative Transportation</td>
<td>4</td>
</tr>
<tr>
<td>5.1</td>
<td>Site Development, Protect or Restore Habitat</td>
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</tr>
<tr>
<td>5.2</td>
<td>Site Development, Maximize Open Space</td>
<td>1</td>
</tr>
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<td>6.1</td>
<td>Stormwater Design, Quantity Control</td>
<td>1</td>
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<tr>
<td>6.2</td>
<td>Stormwater Design, Quality Control</td>
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<td>7.1</td>
<td>Heat Island Effect, Non-Roof</td>
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<tr>
<td>7.2</td>
<td>Heat Island Effect, Non-Roof</td>
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<td>7.3</td>
<td>Heat Island Effect, Non-Roof</td>
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<tr>
<td>7.4</td>
<td>Heat Island Effect, Roof</td>
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<tr>
<td>8</td>
<td>Light Pollution Reduction</td>
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</tbody>
</table>

### LEED credit for asphalt

- Stormwater Design
- Heat Island Effect
| Prereq 1 | Storage & Collection of Recyclables | Required |
| Credit 1.1 | **Building Reuse**, Maintain 75% of Existing Walls, Floors & Roof | 1 |
| Credit 1.2 | **Building Reuse**, Maintain 95% of Existing Walls, Floors & Roof | 1 |
| Credit 1.3 | **Building Reuse**, Maintain 50% of Interior Non-Structural Elements | 1 |
| Credit 2.1 | **Construction Waste Management**, Divert 50% from Disposal | 1 |
| Credit 2.2 | **Construction Waste Management**, Divert 75% from Disposal | 1 |
| Credit 3.1 | **Materials Reuse**, 5% | 1 |
| Credit 3.2 | **Materials Reuse**, 10% | 1 |
| Credit 4.1 | **Recycled Content**, 10% (post-consumer + 1/2 pre-consumer) | 1 |
| Credit 4.2 | **Recycled Content**, 20% (post-consumer + 1/2 pre-consumer) | 1 |
| Credit 5.1 | **Regional Materials**, 10% Extracted, Processed & Manufactured Regionally | 1 |
| Credit 5.2 | **Regional Materials**, 20% Extracted, Processed & Manufactured Regionally | 1 |
| Credit 6 | **Rapidly Renewable Materials** | 8 credits |
| Credit 7 | **Certified Wood** | 1 |
## LEED for Retail - New Construction and Major Renovations

<table>
<thead>
<tr>
<th>Category</th>
<th>Possible Points</th>
<th>LEED process</th>
<th>Notes</th>
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<tbody>
<tr>
<td>Sustainable Sites:</td>
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<td>Water Efficiency:</td>
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<td>+</td>
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<td>8</td>
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<tr>
<td>Energy &amp; Atmosphere:</td>
<td>17</td>
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<td>Reuse up to 10%</td>
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<tr>
<td>Indoor Environ. Quality:</td>
<td>14</td>
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<td>Recycled up to 20%</td>
</tr>
<tr>
<td>Innovation &amp; Design:</td>
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<td>13</td>
<td></td>
</tr>
</tbody>
</table>

**Retail Certification Levels**
- Certified: 26-32 points
- Silver: 33-38 points
- Gold: 39-51 points
- Platinum: 52-70 points
Asphalt pavement is positioned nicely

- Recycled (re-used) and recyclable
  - Innovation credit every 5% more than 10% / 20% reused / recycled – petition USGBC LEED
- Local materials
- Stormwater management
- UHI: need to work through the “process”
  - Comfort issue under limited circumstances
  - Porous pvmts / OGFC might mitigate – petition
  - Asphalt reflective pavements can be produced
Common Recycled Materials in Asphalt Pavements

- Shingles
- Crumb / Tire Rubber
- Glass
- Slag
- Foundry sand

All are in different stages of utilization / evaluation
scrap tires

USES OF SCRAPPED TIRES

Fuel (cement kilns, pulp & paper, power plants) - 42%

Civil Works (roadbeds, drainage liners) - 14%

Landfills - 10%

Ground/crumb rubber - 12%

Stamped (doormats/sandals) - 3%

Agra & Misc (tire swings, planters, art) - 2%

Dumps, Stockpiles & processors - 12%

Export - 5%

NAPA
milling asphalt pavement
reclaimed asphalt pavement “RAP”
sizing RAP
processing RAP
Reclaimed Asphalt Pavement “RAP”

- Removed and/or reprocessed pavement materials containing asphalt and aggregates
- Over 80 percent of the asphalt pavement, removed each year for widening and resurfacing, is re-used
- Represents close to 100 million tons / year
- RAP is the Nation’s No. 1 recycled material in both total amount and percentage recycled
Glass bottles
Paper
Newsprint
Aluminum cans
Scrap Steel
Asphalt Pavmt

Percent Recycled

FHWA / USEPA Report to Congress, EPA/600/R-93/095.
RAP: sustainable & carbon neutral

30,000 Tons of RAP = 70 - 6,000 Gallon Transport Trailers and 28,200 Tons of Clean Aggregate
Leadership in Energy and Environmental Design

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  - Guidelines for Multiple Buildings and On-Campus Building Projects
- LEED for Schools
- LEED for Retail
**What is Green Roads?**

*Green Roads* is a rating system that distinguishes high-performance sustainable new, reconstructed or rehabilitated roads. It awards credits for approved sustainable or environmentally friendly choices/practices and can be used to certify projects based on total point value. *more...*

---

**Why? Assessment & Information**

*Green Roads* provides (1) a quantitative means to assess the sustainability and environmental stewardship of roads, and (2) a tool for decision-makers that allows them to make informed design and construction decisions regarding sustainability and environmental stewardship of a road.
The Partnership

The Green Highways Partnership (GHP) is a voluntary, public/private initiative that is revolutionizing our nation’s transportation infrastructure. Through concepts such as integrated planning, regulatory flexibility, and market-based rewards, GHP seeks to incorporate environmental streamlining and stewardship into all aspects of the highway lifecycle.

With an extensive network of environmental, industrial and governmental collaborators, GHP believes active cooperation and regulatory progressiveness are critical in moving beyond the current paradigm. The combined resources of our partner base allow Green Highways to ensure that sustainability becomes the driving force behind infrastructure development. By harnessing the power of the

Spotlight

GHPodcast
New GHPodcasts feature the latest GHP developments.

ACPA Award
EPA’s Dominique Lueckenhoff, first recipient of Outstanding Health, Safety & Environmental Stewardship Award.
The BEES (Building for Environmental and Economic Sustainability) software brings to your fingertips a powerful technique for selecting cost-effective, environmentally-preferable building products. Developed by the NIST (National Institute of Standards and Technology) Building and Fire Research Laboratory, the tool is based on consensus standards and designed to be practical, flexible, and transparent. Version 4.0 of the Windows-based decision support software, aimed at designers, builders, and product manufacturers, includes actual environmental and economic performance data for 230 building products.

In support of the 2002 Farm Security and Rural Investment Act (P.L. 107-171), BEES has been adapted for application to biobased products. For more information about this program, go to BEES for USDA.

BEES measures the environmental performance of building products by using the life-cycle assessment approach specified in the ISO 14040 series of standards. All stages in the life of a product are analyzed: raw material acquisition, manufacture, transportation, installation, use, and recycling and waste management. Economic performance is measured using the ASTM standard life-cycle cost method, which covers the costs of initial investment, replacement, operation, maintenance and repair, and disposal. Environmental and economic performance are combined into an overall performance measure using the ASTM standard for Multi-Attribute Decision Analysis. For the entire BEES analysis, building products are defined and classified according to the ASTM standard classification for building
Overall Performance

Note: Lower values are better

Score

100% Portland Cement
20% Fly Ash Cement
Asphalt/Tradl Maint
Lafarge Alpena I

 Alternatives

pts

Economic Performance
Environmental Performance

BEES
Environmental Performance

Note: Lower values are better
Human Health Cancer by Sorted Flows*

Note: Lower values are better

<table>
<thead>
<tr>
<th>Category</th>
<th>100% OPC</th>
<th>20% FlyAsh</th>
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<td>Cancer--(a) Dioxins (unspecifie)</td>
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<td>1,660.52</td>
<td>0.41</td>
<td>0.49</td>
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* NAPA BEES
proof of global warming
Global Warming by Life-Cycle Stage

Note: Lower values are better
Production of HMA pavement requires ~ 20% less ENERGY than vs construction of PCC pavement – but difficult to quantify

UHI may be “real” but is only local; NOT a contributor to Global Warming – Scientific American

Avg. automobile emits ~ 6 tons CO2 annually
Avg. HMA plant emits ~ 2,500 tons CO2 = ~ 0.0023 Tg
Cement industry emits ~ 45 Tg CO2
HMA pavement unit @ ~ 30% vs. PCConcrete (BEES)

Very few existing published info. but general support

So, where is HMA industry vs. all GHG emissions . . .
Figure ES-5: 2005 Sources of CO$_2$
Figure ES-5: 2005 Sources of CO₂

- Fossil Fuel Combustion: 5,751.2 Tg CO₂ Eq
- Cement Manufacture

CO₂ as a Portion of all Emissions: 83.9%

carbon footprint: US sources
Figure ES-6: 2005 CO$_2$ Emissions from Fossil Fuel Combustion by Sector and Fuel Type
The entire annual CO2 / greenhouse gas emissions / carbon footprint from a typical hot-mix plant (~ 2,500 tons) could be totally offset by using greater than ~ 25% RAP in pavement mix designs -- accomplished by minimizing acquisition of energy intensive (natural) raw materials such as aggregate and petroleum asphalt.
continually changing technology . .
to drive efficiency = $$ / env comp
This Street Paved With Environmentally Friendly Warm Mix Asphalt

York County
South Carolina

ASTEC

Boggs
PAVING, INC.
GREEN

Warm Mix Asphalt (“WMA”)
Many different technologies
- Additives such as waxes and zeolites
- Emulsions and water foaming processes
- Costs differ; some higher, some lower

End-result: to lower mix temperatures from 300 °F → ~ 250 °F (or lower)
- Less energy demand / fuel consumption
- Less emissions: plant and field

Quantifying energy and emissions
- ~ 15% less fuel consumption
- ~ 20% less CO2 emissions
- Lower NOx, particulate, other emissions

States, Producers, Contractors, FHWA all interested
- TRB funding @ ~ $2MM; performance/ emissions
ASPHALT: the environmentally sustainable pavement

- Porous pavements manage stormwater
- OGFCs are safe and quiet
- Reflective / OGFC / Porous can mitigate UHI
  - Remember: UHI doesn’t cause Global Warming
- Great pavement to help with LEED certification
  - Additional credits are possible
- Asphalt pavements accept recycled goods / are recycled (RAP)
- HMA pavements are environmentally preferred
  - Less energy to construct, low carbon footprint, speed of construction, no emissions like dioxins
- Warm Mix lowers energy consumption & emissions
- RAP can offset the entire annual HMA GHG emissions

greening the blacktop
Questions ??

"it ain't easy being green!"
Questions ??

Getting “credit” for energy / GHG reductions: LEED / cap-and-trade

“it ain’t easy being green!”
Asphalt is the sustainable material for constructing pavements. From the production of the paving material, to the placement of the pavement on the road, to rehabilitation, through recycling, asphalt pavements minimize impact on the environment. Low consumption of energy for production and construction.