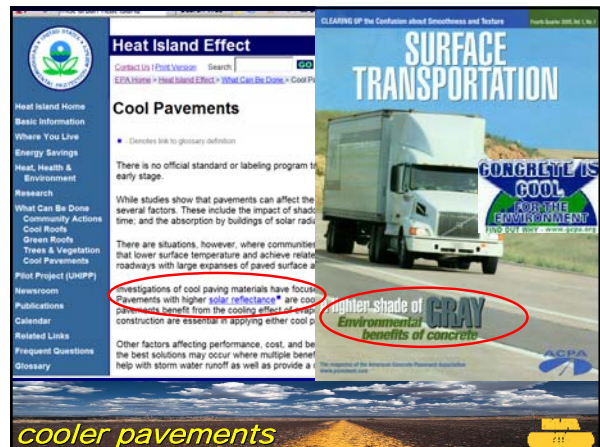


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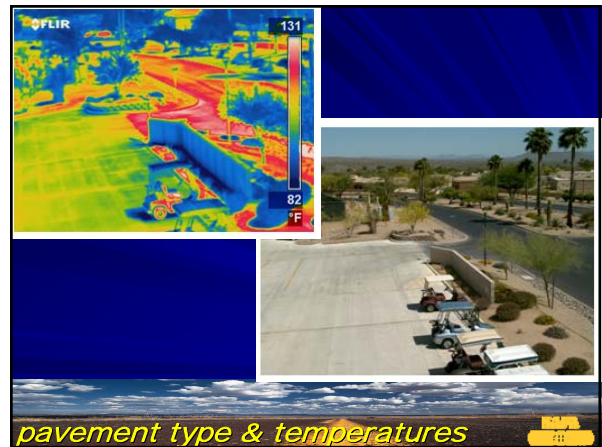
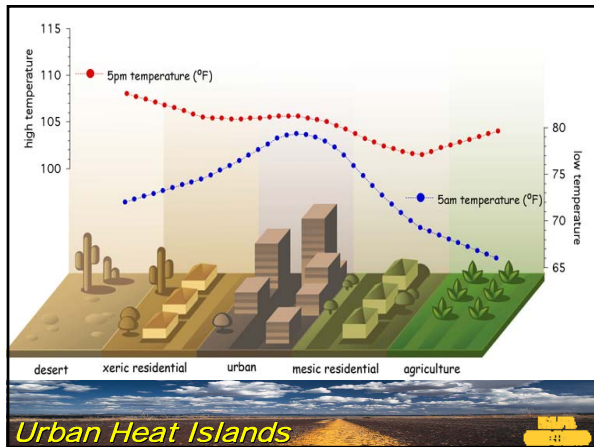
Heat Island Effect
 Cool Pavements
 There is no official standard or testing program in early stages.
 Other studies show that pavements can be cooled by several factors. These include the color, the absorption rate, and the evaporation rate.
 There are situations where pavement materials have been used to cool pavements. These include the use of reflective materials, the use of reflective pigments, and the use of reflective pigments in the concrete surface.
 These materials have been used to cool pavements. These include the use of reflective materials, the use of reflective pigments, and the use of reflective pigments in the concrete surface.
 These materials have been used to cool pavements. These include the use of reflective materials, the use of reflective pigments, and the use of reflective pigments in the concrete surface.

It's NOT a black and white issue

cooler pavements

URBAN HEAT ISLAND
 Little vegetation or evaporation causes cities to remain warmer than the surrounding countryside

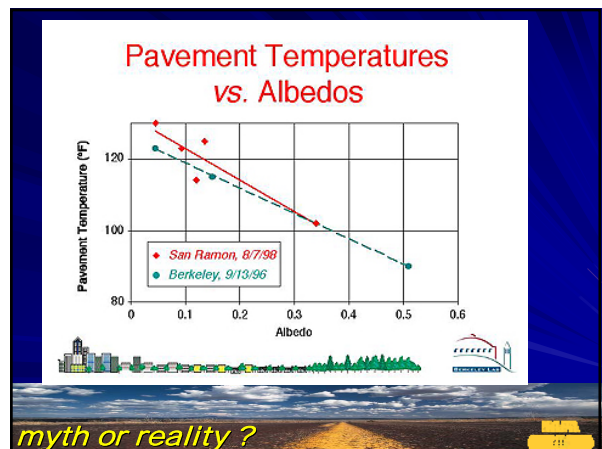
Urban Heat Islands



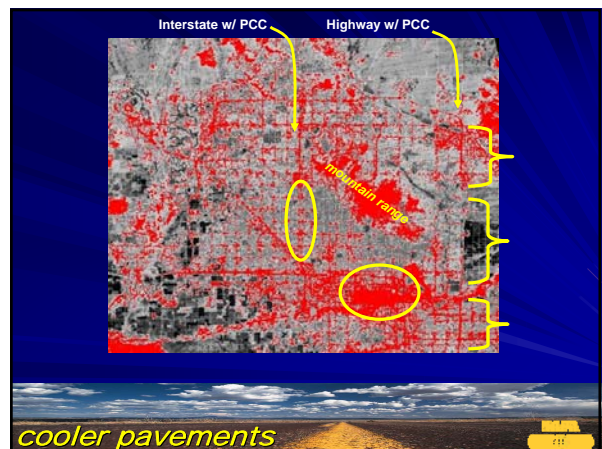
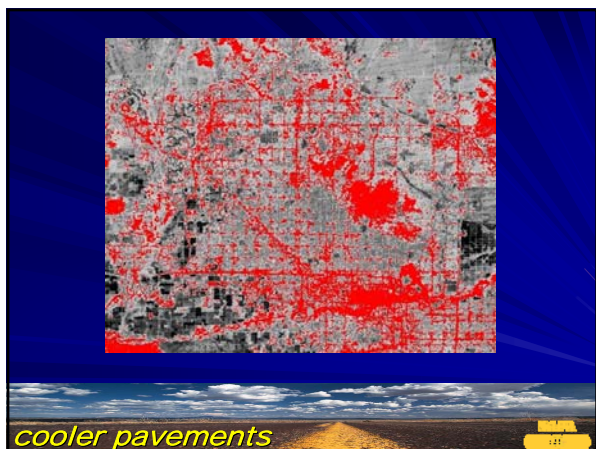
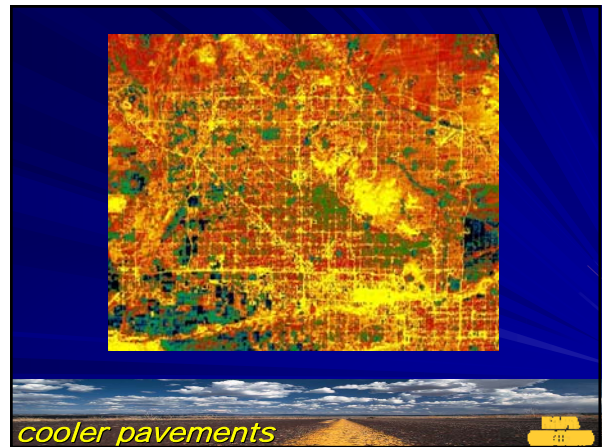
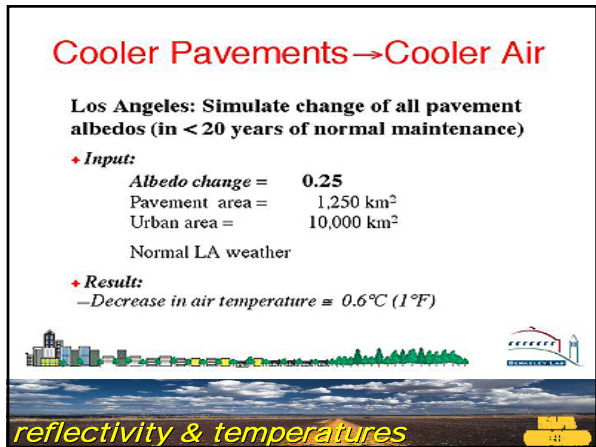
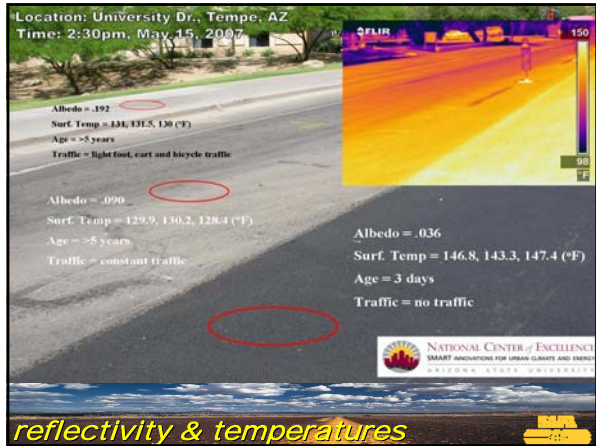
Location: University Dr., Tempe, AZ
 Time: 2:30pm, May 15, 2007

Albedo	Surf. Temp (°F)	Age	Traffic
0.192	134, 135, 130	> 5 years	light foot, cart and bicycle traffic
0.090	129.9, 130.2, 128.4	> 5 years	constant traffic
0.036	146.8, 143.3, 147.4	3 days	no traffic

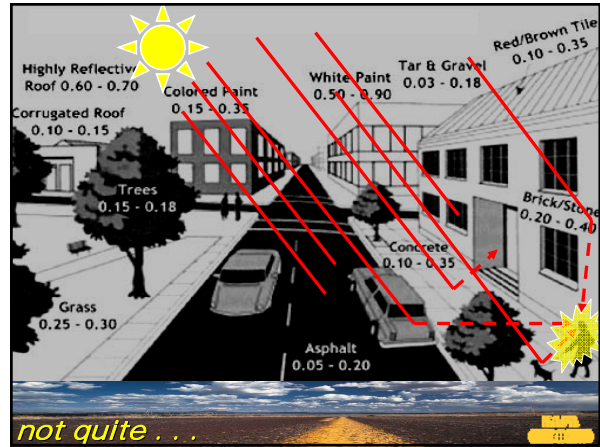
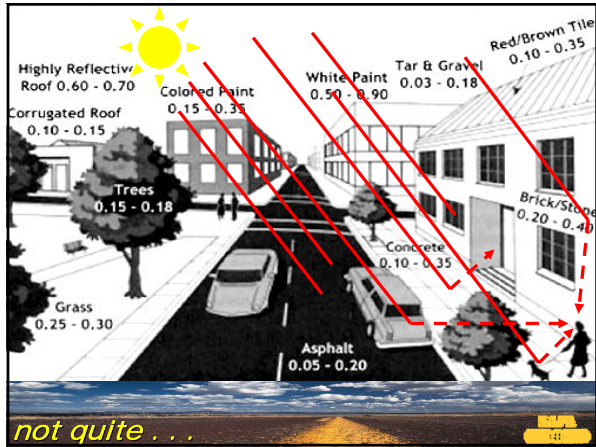
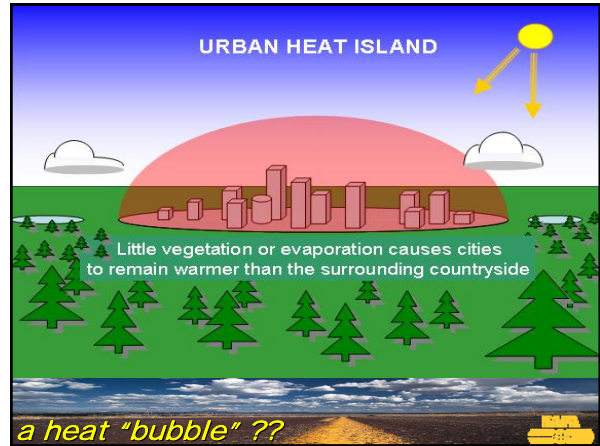
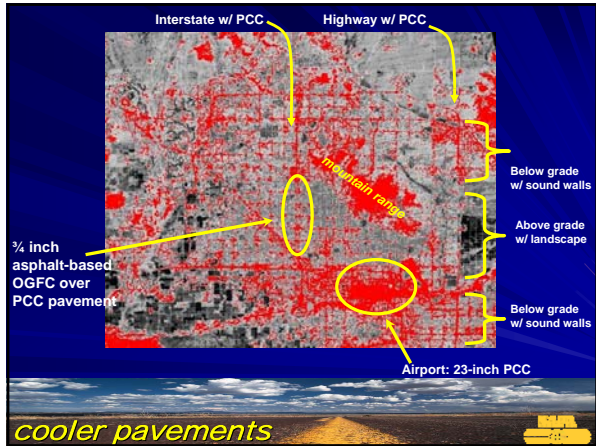
reflectivity & temperatures



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- What happens after solar radiation strikes a pvmt surface
 - Dark pavements absorb / re-radiate as heat (night)
 - Light pavements reflect as UV radiation (day)
 - Heats up near-surface air / Heats up buildings
 - Provides catalyst for increasing ground-level ozone
 - Increases potential personal UV radiation exposure
 - Pavement thickness and material capacities
 - Thicker pavements retain more heat (Phoenix)
 - (near) surface temperature vs air temperature
 - Pvmt design has “net zero” balance on UHI temperatures
 - Concrete pvmt is NOT necessarily cooler than asphalt
 - Porous (OGFC) asphalt pavements are COOLER
 - UHI does NOT cause Global Warming . . . Sci. Am.
 - specialized binders are expensive but . . .
- think about it . . .*

Surface Chip Seals and Coatings: using reflective / light-colored chip / paints

reflective pavements



- 20,000 sq. ft. parking lot
 - Conventional HMA @ ~ \$1.35 sq ft.
 - \$400/ton binder, 3" thick, \$75/ton HMA, ~ 400 tons HMA total
 - PCConcrete pvmt @ ~ \$5.75 sq ft.
 - standard depth of ~ 6-8" w/ wire mesh etc; range \$4 - \$8
 - Colored HMA pvmt @ ~ \$2.50 sq ft.
 - \$2,000/ton binder, 3", = ~ \$140/ton HMA; material costs / placed
 - more labor involved re cleaning plant equip etc
 - Densiphalt (cement grout over OGFC) @ ~ \$4 sq ft
 - includes placement of 2" OGFC only + std labor;
 - range \$3.50 - \$5; process needs an existing (HMA) pvmt base
 - Other technologies . . .
 - specialized binders are expensive but . . .
- sq. ft. cost basis*

- \$2,000 / ton binder only doubles the sq. ft price
 - Triple current HMA price is still competitive
 - Densiphalt is current “alternative” to PCC for LEED credit – customers are purchasing
 - Small volumes, specialized market, but GROWING
 - Other technologies are much less \$\$
 - HOW and WHY does this fit into LEED ???
 - specialized binders are expensive but . . .
- sq. ft. cost basis*

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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 . . .

cooler pavements

- HOW and WHY does this fit into LEED ???

- specialized binders are expensive but . . .

cooler pavements

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LEED

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's lifecycle. Specific LEED programs include:

- **Item: Commercial Construction and Major Renovation projects**
- **Existing Building Operations and Maintenance**
- **Collaborative for Schools**
- **Core and Shell Development projects**
- **Homes**
- **Neighborhood Development**
- **Guidelines for Multiple Buildings and On-Campus Building Projects**

LEED for Schools
LEED for Retail

LEED

LEED: Leadership in Energy and Environmental Design

- 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 process

Green Building Rating System

LEED for Retail - New Construction and Major Renovations

Retail Certification Levels

Certified: 26-32 points
Silver: 33-38 points
Gold: 39-51 points
Platinum: 52-70 points

Category	Possible Points
Sustainable Sites:	16
Water Efficiency:	5
Materials & Resources:	13
Energy & Atmosphere:	17
Indoor Environ. Quality:	14
Innovation & Design:	5

LEED process

Sustainable Sites **16 Possible Points**

Prereq	Construction Activity	Pollution Prevention	Required
Credit 1	Site Selection		1
Credit 2	Development Density & Community Connectivity		1
Credit 3	Brownfield Redevelopment		1
Credit 4	Alternative Transportation		4
	A. Public Transportation Access (1 point)		
	B. Bicycle Storage & Commuting (1 Point)		
	C. Low Emitting & Fuel Efficient Vehicles (1 Point)		
	D. Parking Capacity (1 Point)		
	E. Delivery Service (1 Point)		
	F. Incentives (1 Point)		
	G. Car-Share Membership (1 Point)		
	H. Alternative Transportation Education (1 Point)		
Credit 5.1	Site Development, Protect or Restore Habitat		1
Credit 5.2	Site Development, Minimize Open Space		1
Credit 6.1	Stormwater Design, Quality Control		1
Credit 6.2	Stormwater Design, Quality Control		1
Credit 7.1	Heat Island Effect, Non-Roof		1
Credit 7.2	Heat Island Effect, Non-Roof		1
Credit 7.3	Heat Island Effect, Non-Roof		1
Credit 7.4	Heat Island Effect, Roof		1
Credit 8	Light Pollution Reduction		1

5 credits

LEED credit for asphalt

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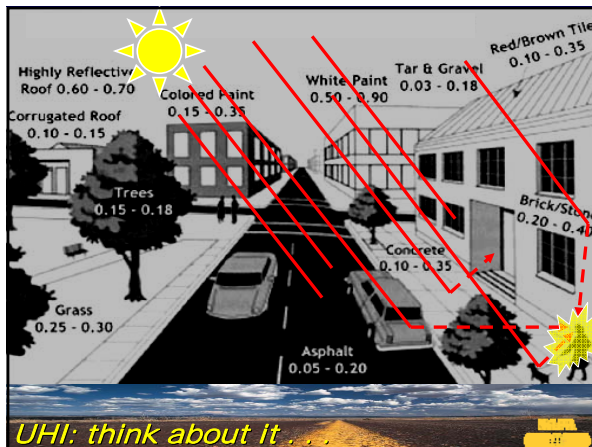
Materials & Resources		13 Possible Points
Prereq 1	Storage & Collection of Recyclables	Required
Credit 1.1	Building Reuse, Maintain 75% of Existing Walls, Floors & Roof	1
Credit 1.2	Building Reuse, Maintain 95% of Existing Walls, Floors & Roof	1
Credit 1.3	Building Reuse, Maintain 50% of Interior Non-Structural 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	1
Credit 7	Certified Wood	1

LEED credit for asphalt

Green Building Rating System		Retail Certification Levels	
LEED for Retail - New Construction and Major Renovations		Certified: 26-32 points	
		Silver: 33-38 points	
		Gold: 39-51 points	
		Platinum: 52-70 points	
Category	Possible Points		
Sustainable Sites:	16	5	
Water Efficiency:	5	+	
Materials & Resources:	13	6	
Energy & Atmosphere:	17		
Indoor Environ. Quality:	14		
Innovation & Design:	5		

LEED process

- 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
 - Overall environmental impact might be less, e.g., UV radiation
 - Porous pvmts / OGFC might mitigate – petition
 - By Show of Hands . . . Lost jobs to reflectivity?
- LEED: sustainable pavement*



- Asphalt: the environmentally sustainable pavement
 - Asphalt pvmts accept recycled goods / are recycled
 - Porous pavements manage stormwater
 - Asphalt Pavements require less energy to construct (carbon footprint & construction speed)
 - Warm Mix lowers energy consumption & emissions
 - RAP can offset HMA GHG emissions
- greening the blacktop*



Common Recycled Materials in Asphalt Pavements

- Shingles
- Crumb / Tire Rubber
- Glass
- Slag
- Foundry sand
- All are in different stages of utilization / evaluation

recycled pavement



USES OF SCRAPPED TIRES

Use	Percentage
Fuel (cement kilns, pulp paper, power plants)	42%
Landfills	10%
Civil Works (roadbeds, drainage liners)	14%
Ground rubber	12%
Dumps, Shredders & processors	12%
Export	5%
Stamped (doormats/sandals)	3%
Agri & Misc (tire swings, planters, art)	2%

scrap tires

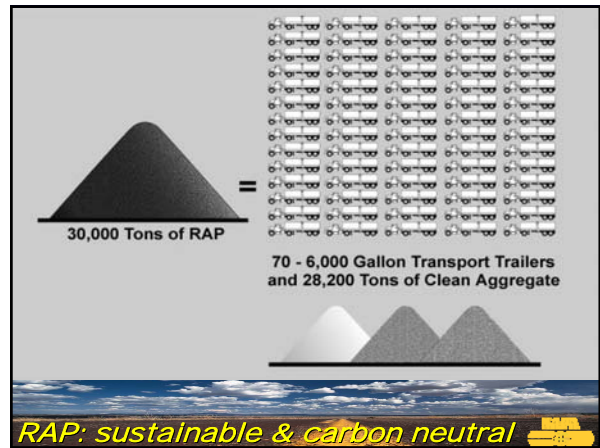
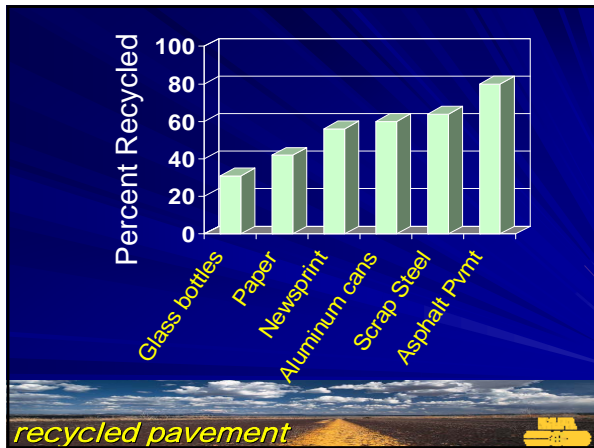


Reclaimed Asphalt Pavement "RAP"

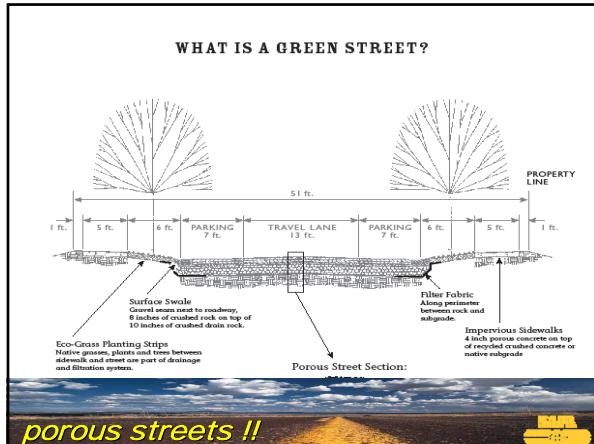
- Removed and/or reprocessed pavement materials containing asphalt and aggregates
- Over 80 percent of the asphalt pavement, removed each year for widening and resurfacing, is re-used
- Represents close to 100 million tons / year
- RAP is the Nation's No. 1 recycled material in both total amount and percentage recycled

recycled pavement

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

- New Commercial Construction and Major Renovation projects
- Existing Building Operations and Maintenance
- Green Power Partnership
- Core and Shell Development projects
- Homes
- Neighborhood Development
- International High-Rise Buildings and On-Campus Building Projects
- LEED for Schools
- LEED for Retail

LEED: green metrics

Home Categories Credit Listing Discussion Area Case Studies FAQ

Green Roads
Sustainable and environmentally sound roads for our future

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.

other green metric programs

Green Highways Partnership
Stewardship, Safety, & Sustainability

Home About Partnerships Recognition Opportunities Theme Teams Resource

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 stewardship and stewardship into all aspects of the highway lifecycle.

Spotlight

GHP Podcast
New GHPodcasts feature the latest GHP developments.

ACPA ACPA Award
EPA's Dominique Luedenheff, first recipient of Outstanding Health, Safety & Environmental Stewardship Award.

other green metric programs

Building and Fire Research Laboratory
Office of Applied Economics
NIST National Institute of Standards and Technology

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BEES 4.0

Home

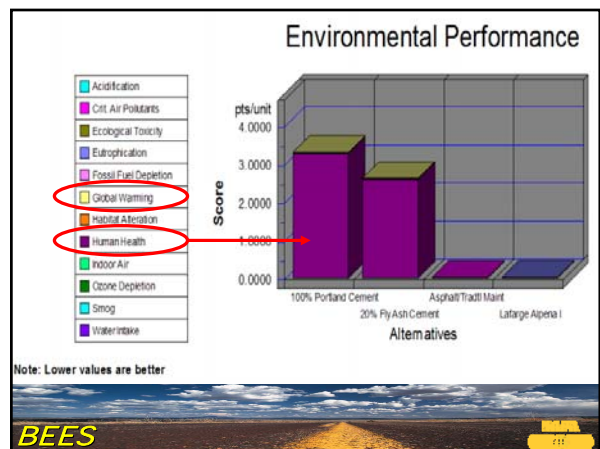
Download BEES Please BEES Model BEES Product BEES Score! What's the Buzz? BEES for USDA

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.

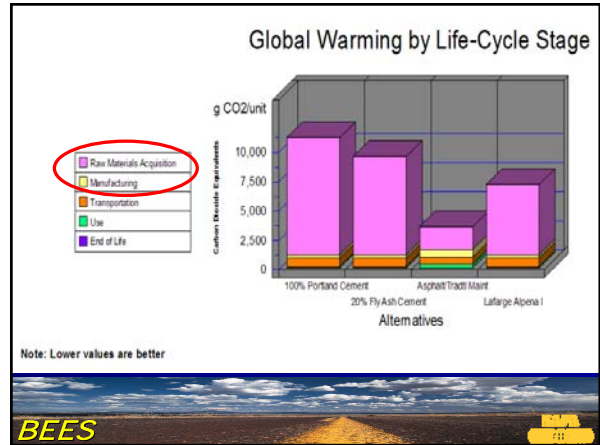
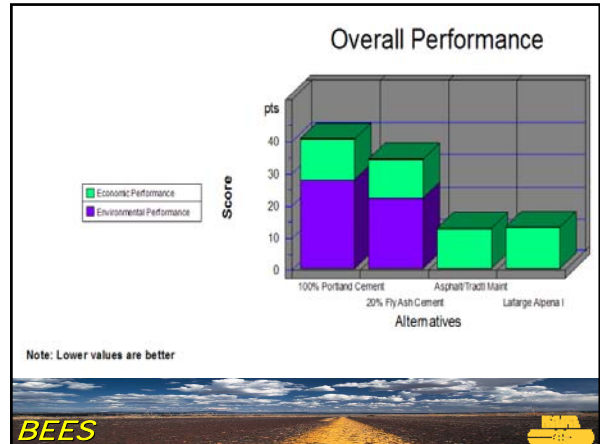
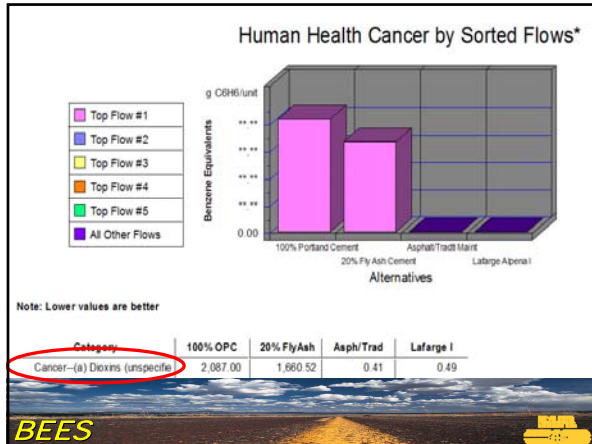
In support of the 2002 Farm Security and Rural Investment Act (P.L. 107-171), BEES has been adapted for application to bio-based products. For more information about this program, go to [BEES for USDA](#).

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

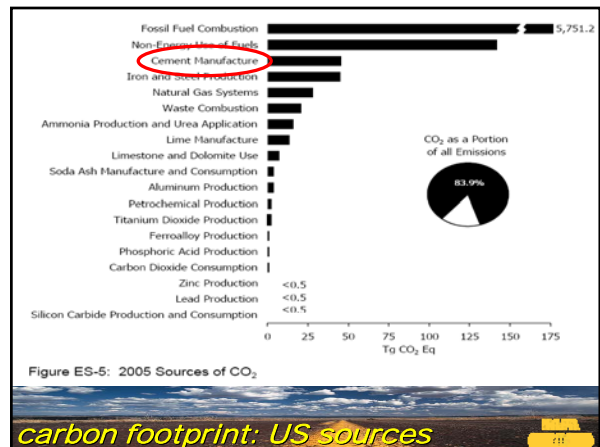
BEES: econ. & env. impacts



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- 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. PCCconcrete (BEES)
 - Very few existing published info. but general support
 - So, where is HMA industry vs. all GHG emissions . . .
- carbon footprint: US sources**
- BEES**



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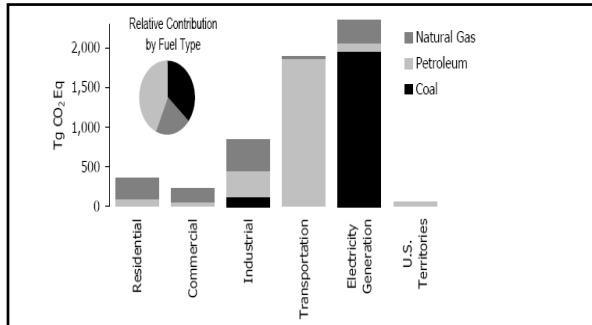
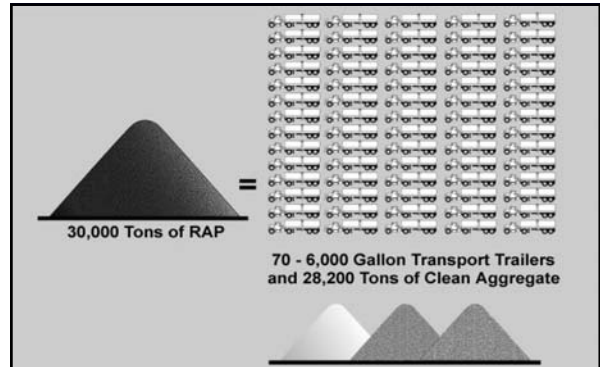


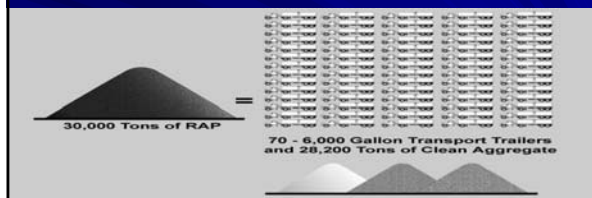
Figure ES-6: 2005 CO₂ Emissions from Fossil Fuel Combustion by Sector and Fuel Type

carbon footprint: US sources



RAP: sustainable & carbon neutral

The entire annual CO₂ / greenhouse gas emissions / carbon footprint from a typical hot-mix plant (~ 2,500 tons) could be totally offset by using 20 - 25% RAP in pavement mix designs -- accomplished by minimizing acquisition of energy intensive (natural) raw materials such as aggregate and petroleum asphalt.



RAP: sustainable & carbon neutral



"it ain't easy being green!"