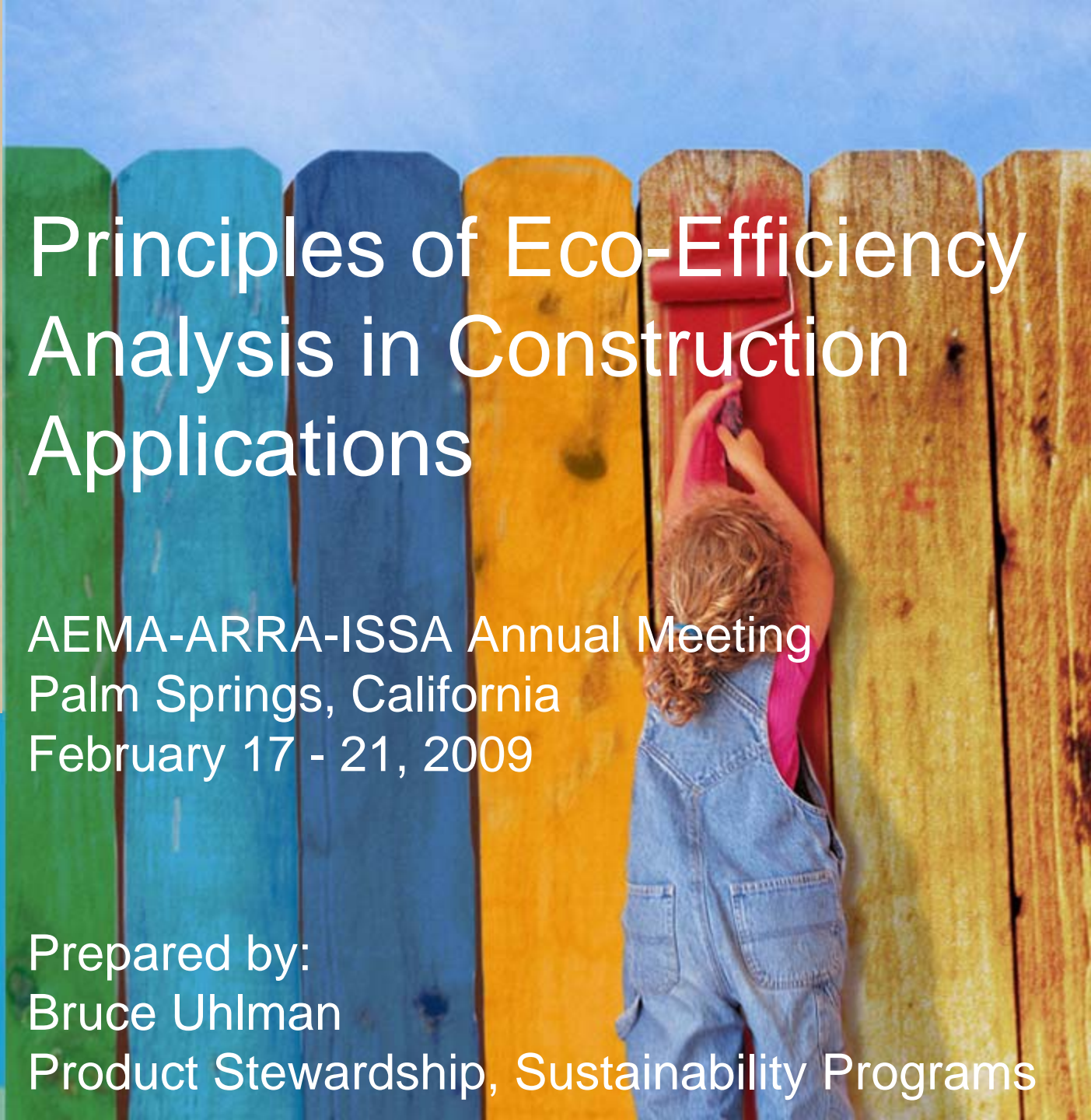




# Principles of Eco-Efficiency Analysis in Construction Applications

AEMA-ARRA-ISSA Annual Meeting  
Palm Springs, California  
February 17 - 21, 2009

Prepared by:  
Bruce Uhlman  
Product Stewardship, Sustainability Programs



# Presentation Outline

- Overview Sustainability
- Measuring Sustainability – Eco-efficiency Analysis
- Eco-efficiency Case Studies in Construction Applications

# Integration of the Three Pillars

## Sustainable Development

**Economy**



**Ecology**



**Social  
Responsibility**



# Sustainability and your Value Chain

## Sustainability Metrics Improve Your Business Value Chain



- Reduce risks
- Strengthen license to operate
- Increase brand value and corporate reputation
- Reduce costs
- Optimize customer processes
- Optimize pricing structure (purchase price vs. system costs)
- Influence regulatory policy

# Sustainability Tools



**“You can only manage what you can measure”**  
Peter Drucker

**Being able to measure sustainability is critical to its successful integration into business strategy**

# Eco-Efficiency Analysis (EEA)

## Sustainability assessment of innovations



**Roland Berger**  
Strategy Consultants

Joint concept  
1996



Independent third  
party validation

- Assessment of equally weighted economic and ecological aspects of products and processes
- Consideration of the entire life cycle (LCA in accordance with ISO norms)
- Eco-efficiency is analyzed from an end use perspective, so comparison is done for a defined level of output
- Standard tool in the BASF Group with more than 380 analyses carried out worldwide.
- Results can support Environmental Product Declaration (EPD) according to ISO14025



**Strategic instrument  
for decision making**

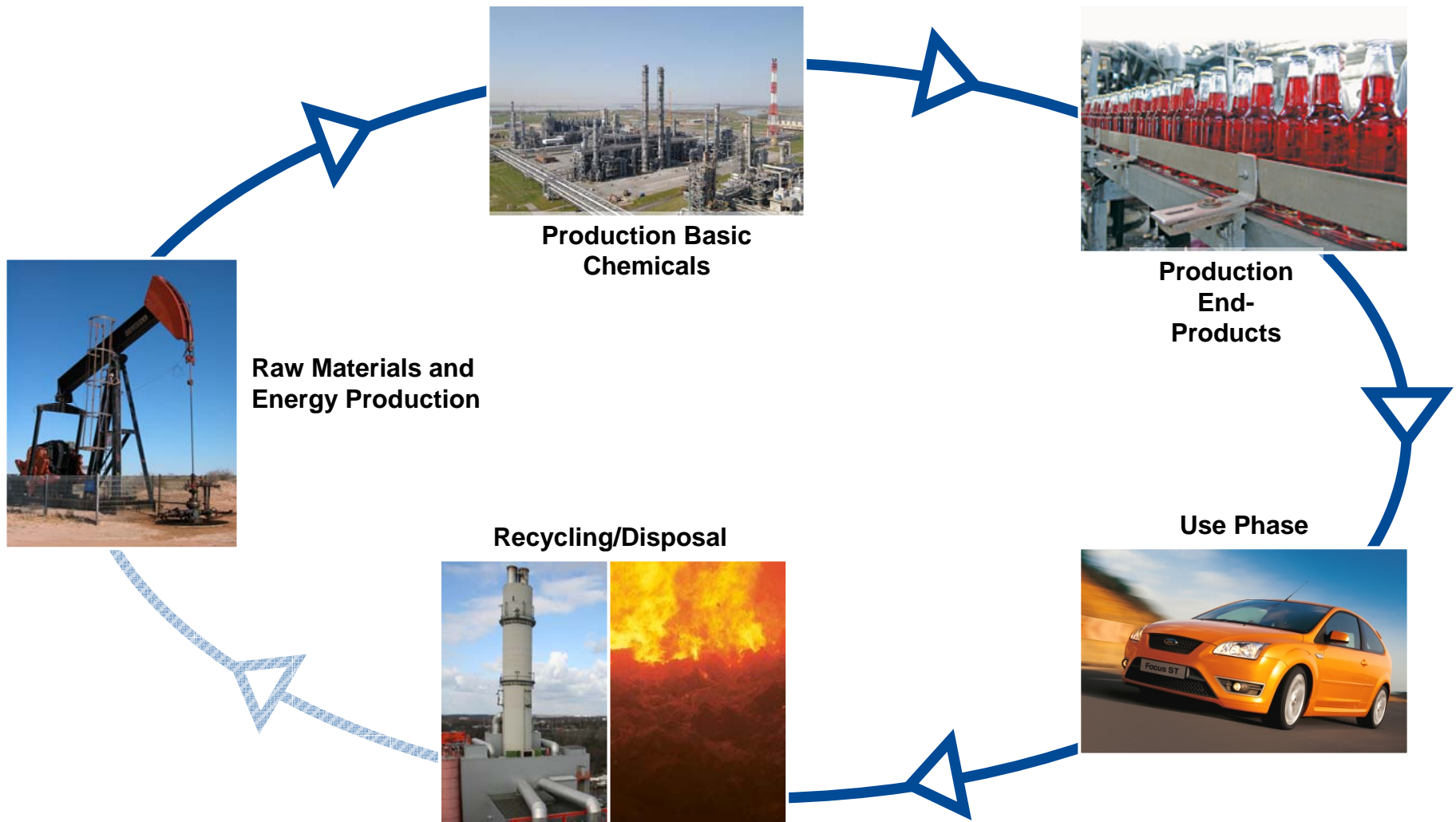


Constant progress  
with partners



Acceptance and  
acknowledgment

# Eco-Efficiency is a Life-Cycle Approach



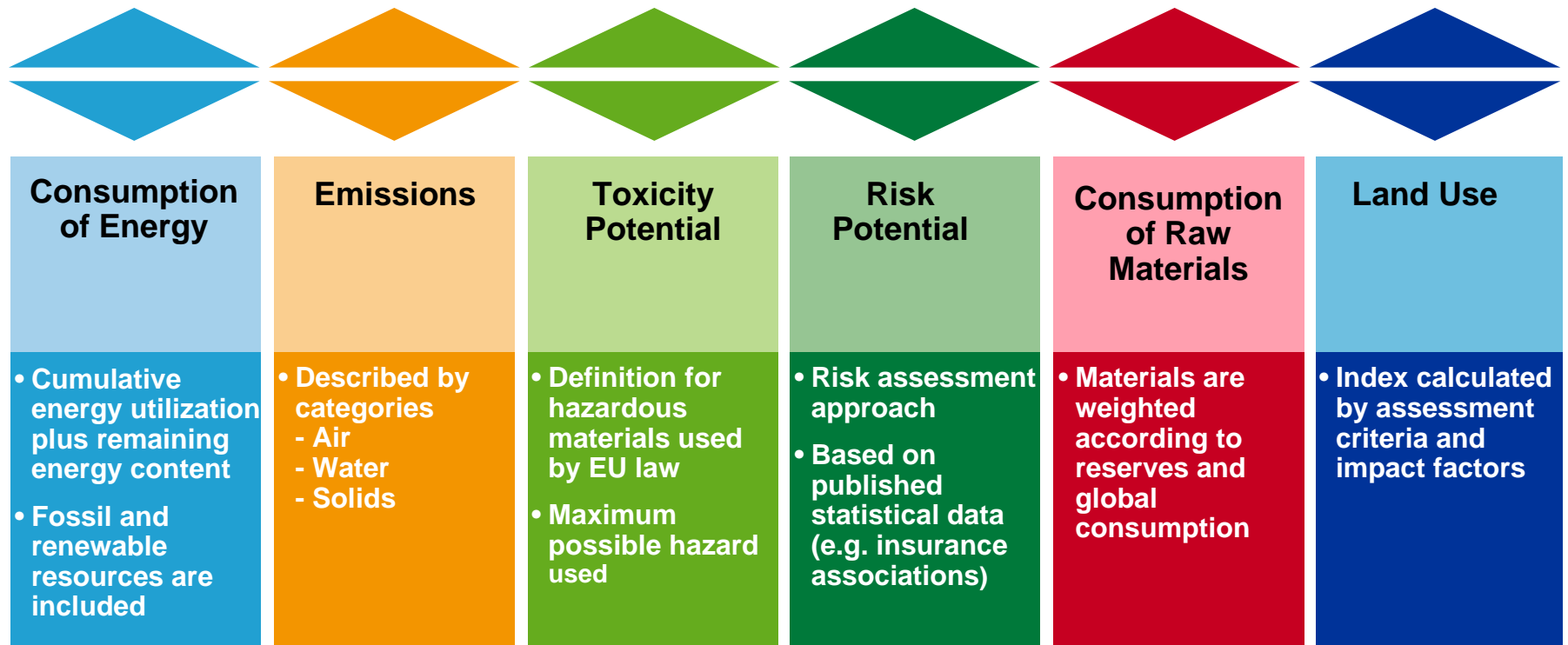
# Economic Impact Categories (over life cycle)

- Raw material costs.
- Labor costs.
- Energy (electric and natural gas).
- Capital & non-capital investment costs.
- Maintenance.
- EH&S programs and regulatory costs.
- Illness & injury costs (medical, legal, lost time).
- Property protection & warehousing costs.
- Waste costs (hazardous, non-hazardous)
- Training costs.
- Other as applicable



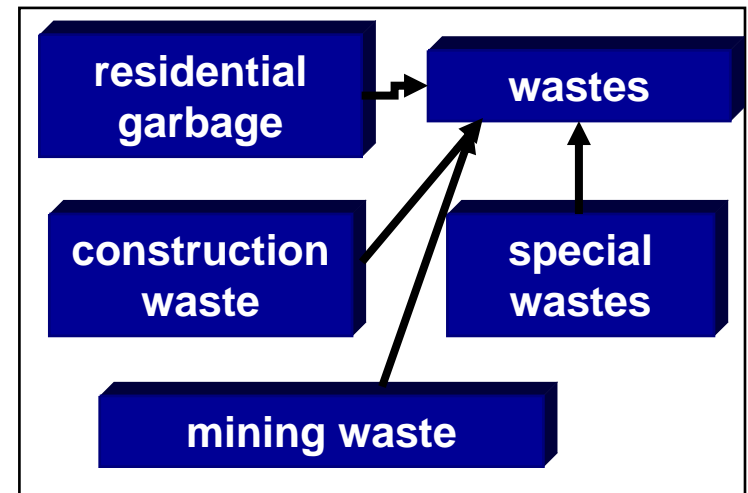
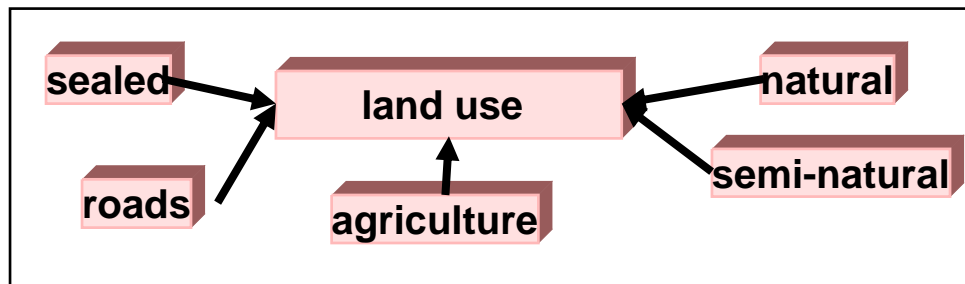
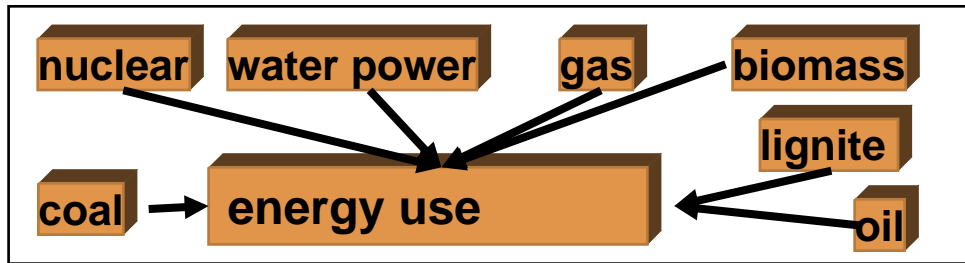
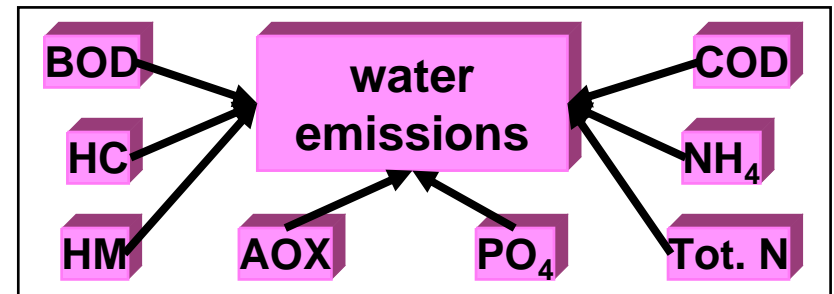
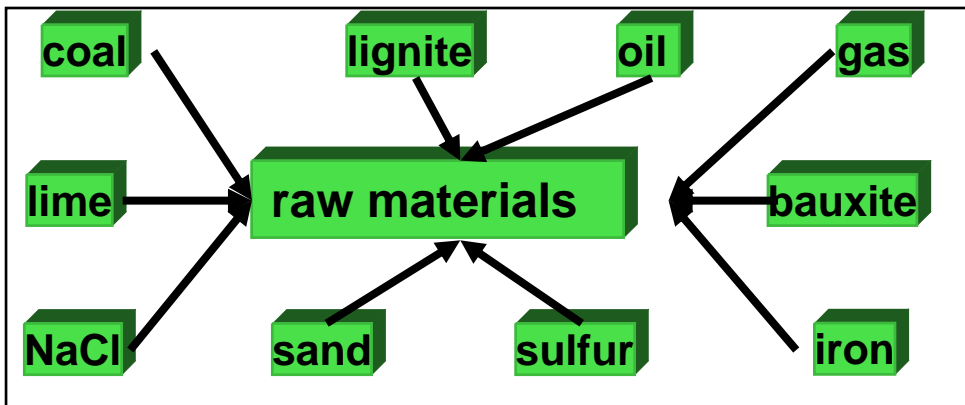
# Environmental Categories

## Environmental impact over the entire life cycle\*

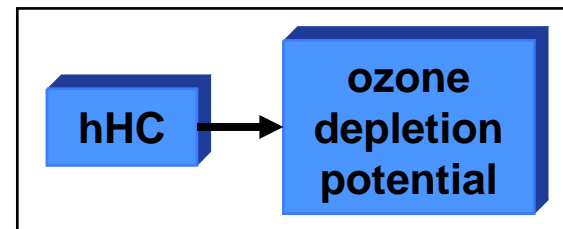
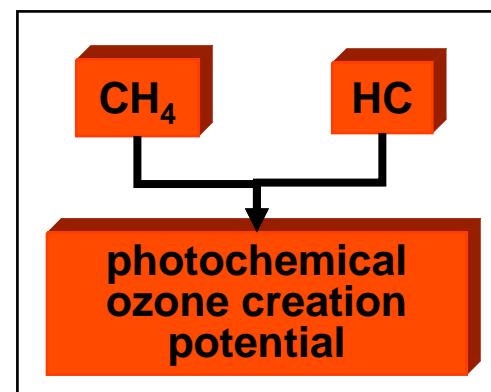
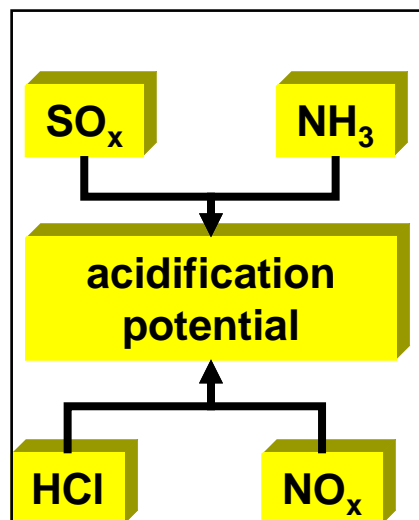
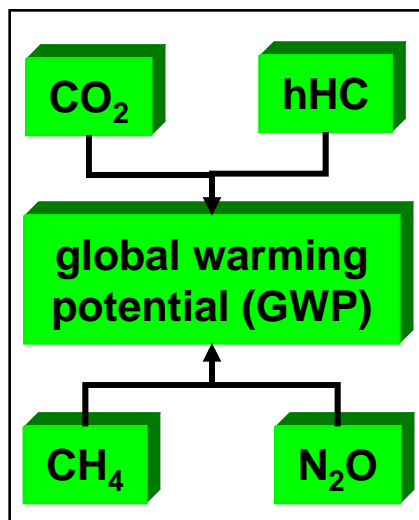


\*Data acquisition and calculation is done according to ISO 14040 and 14044 (ecological part)

# Formation of Effects Categories from Impact Audit



# Formation of Effects Categories from Impact Audit



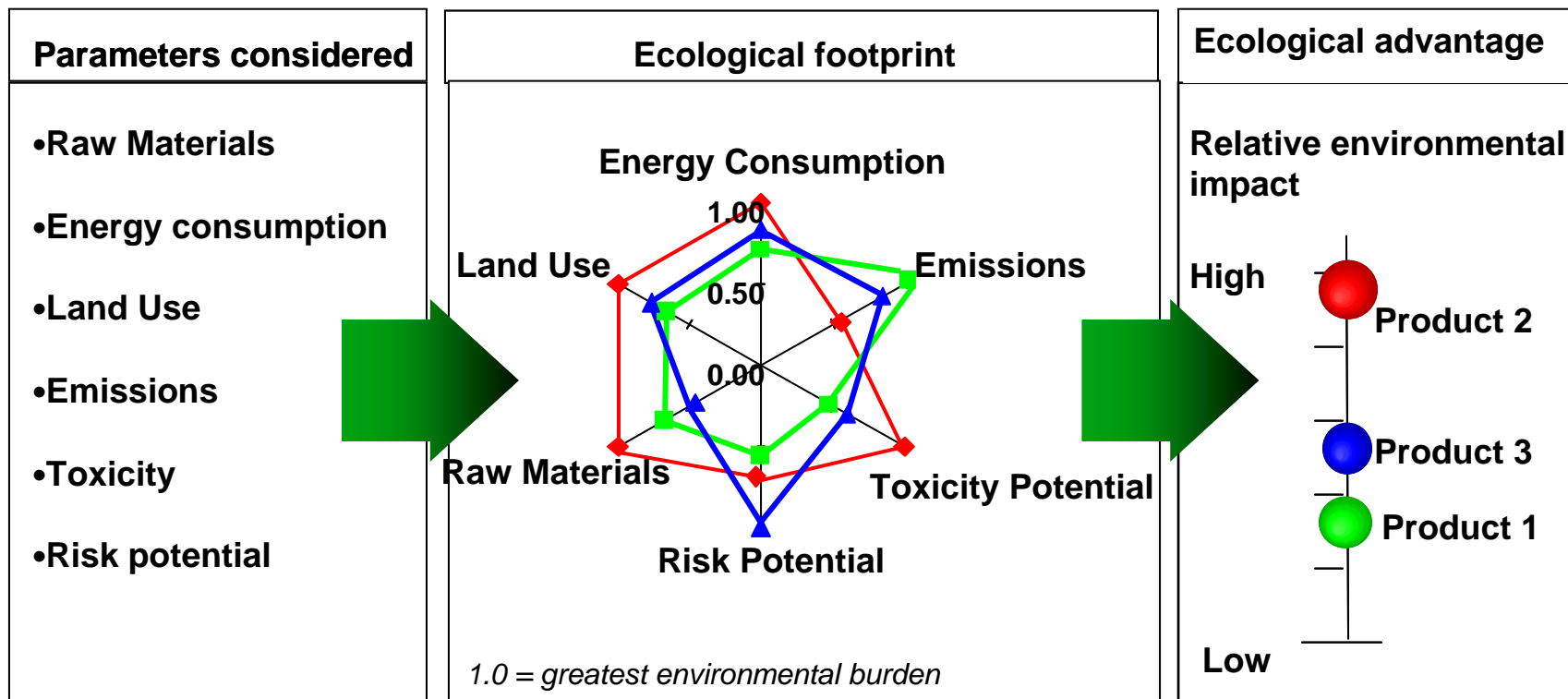
# Typical life cycle Inventory data

life cycle inventory for 1kg of

		units	amount
<b>Fuels</b>			
	coal	MJ	282982
	oil	MJ	4865529
	nat.gas	MJ	5092009
	hydro	MJ	0.12958
	nuclear	MJ	1.18732
	lignite	MJ	0.19356
	recov./d/other	MJ	-1.49745
	biomass	MJ	0.09897
	sum	MJ	10251718
<b>Material</b>			
	water	kg	3.53359
	coal	kg	0.09758
	oil	kg	1.08123
	nat.gas	kg	1.01840
	lignite	kg	0.01019
	NaCl	kg	0.00196
	sulfur	kg	-0.00049
	phosphate	kg	0.00000
	iron	kg	0.00076
	lime	kg	0.00117
	bauxite	kg	0.00072
	sand	kg	0.00058

Air Emissions	units	amount	
	CO2	mg	2737008.25690
	SOX	mg	8287.86116
	NOX	mg	9926.62835
	CH4	mg	7588.77375
	NM-VOCs	mg	2511.43590
	halog. HC	mg	0.35987
	NH3	mg	0.08940
	N2O	mg	0.25430
	HCl	mg	52.65895
<b>Water Emissions</b>			
	COD	mg	182.06441
	BOD	mg	19.17304
	N-tot	mg	5.69960
	NH4	mg	8.58512
	PO4	mg P	0.29616
	AOX	mg	0.00002
	HM	mg	203.27464
	HCl	mg	280.90611
	sulfate	mg	416.78229
	chloride	mg	1587.00285
<b>Solid Wastes</b>			
	municipal	kg	0.00638
	special	kg	0.00620
	construction	kg	0.00001
	mining	kg	0.03978
<b>Land use</b>			
	forest	m2a	0.00000
	pasture, fallow, bio-agric.	m2a	-0.19020
	konv. agriculture	m2a	0.17134
	sealed	m2a	0.01802
	roads, tracks, canals	m2a	0.00087

# Development of Environmental Impacts



Life-cycle data is gathered in six environmental categories and depicted on an ecological footprint. The data are then weighted and aggregated to obtain an overall environmental impact.

# Weighting Factors for the Ecological Impacts

## “societal factor” (qualitative)

What value does society attach to the reduction of the individual potentials?

method:  
public opinion poll

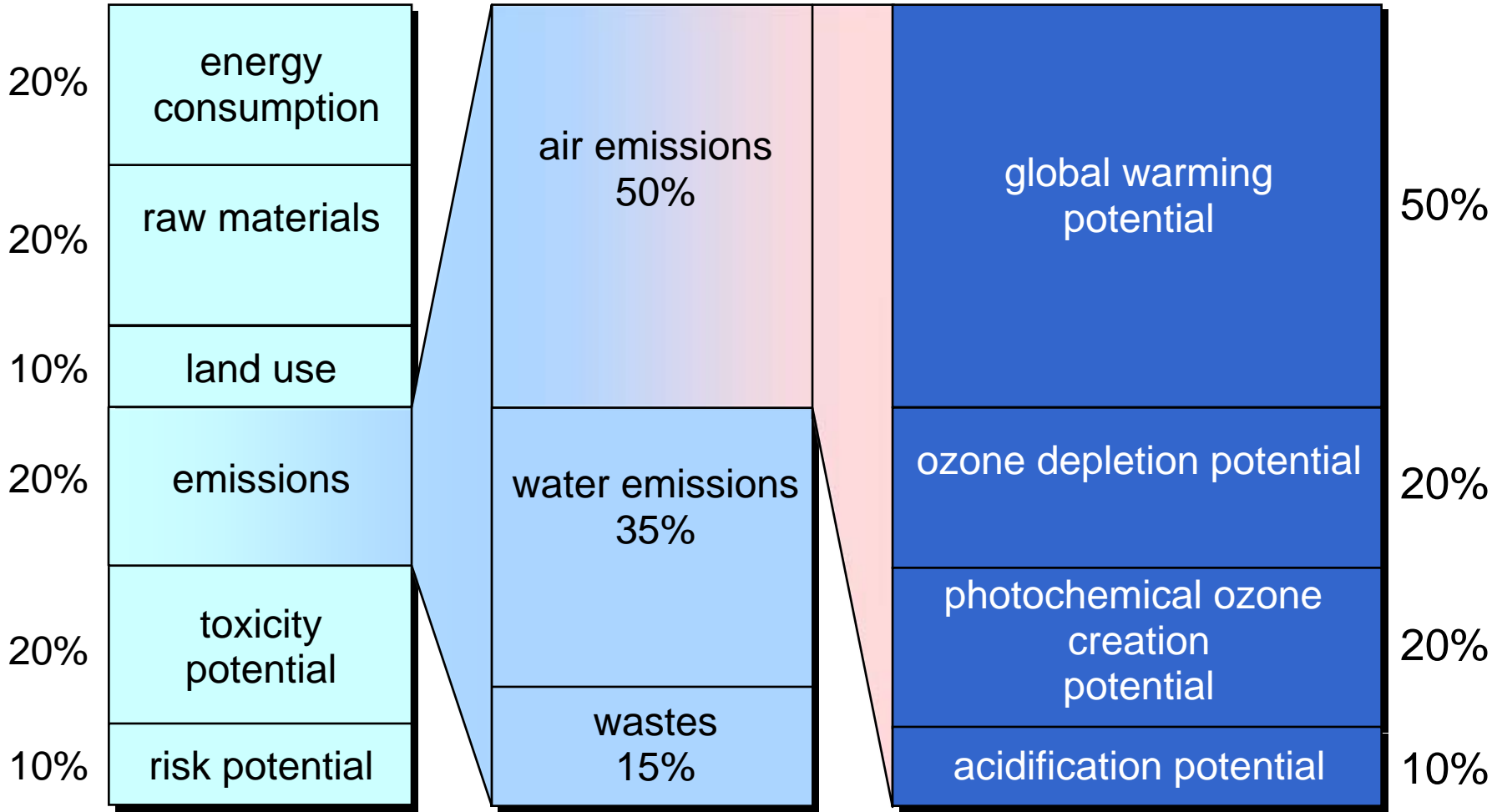
## “relevance factor” (quantitative)

What does the emission (or energy consumption) contribute to the total emissions (or energy consumption) in North America?

method:  
comparison of the data calculated for the alternatives with statistical values for North America

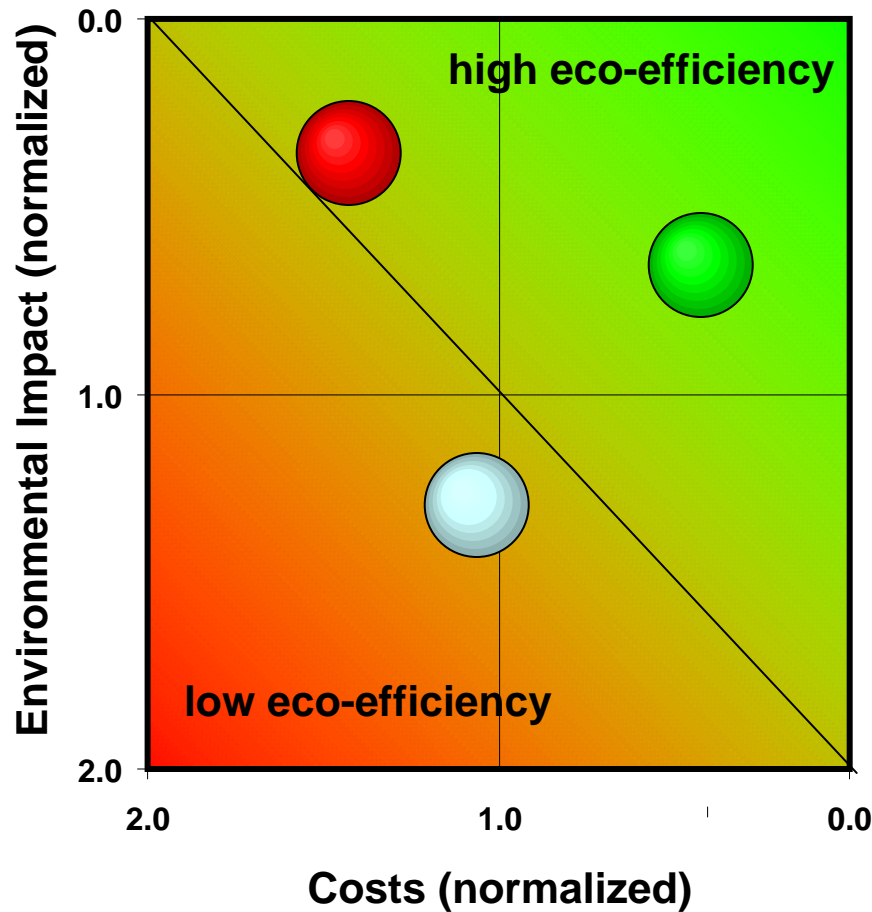
$$\text{Calculation Factor} = \sqrt{\text{Relevance Factor} * \text{Societal Factor}}$$

# Societal Weighting Factors



# Eco-Efficiency Portfolio: Costs and Environmental Burden

Customer benefit :  
1 functional unit for ....



- Alternative A
- Alternative B
- Alternative C

The most eco-efficient product has the lowest environmental impact and cost. Eco-efficiency is measured from the diagonal line.

Alternative A is most eco-efficient.

# Completed Eco-Efficiency Studies

## Transportation Sector

- Chip Seal Asphalt Resurfacing
- Micro-surfacing vs. Thin Hot Mix Asphalt (HMA) Overlays

# The Eco-efficiency of Chip Seals



A collaborative project  
by BASF, AEMA, and  
other industry experts.

# Chip Seal Resurfacing

Customer benefit  
(CB)

- **Resurfacing of a 1-mile, 22-ft wide road stretch, with a lifetime of 7 years, using chipseal**

Hot alternative

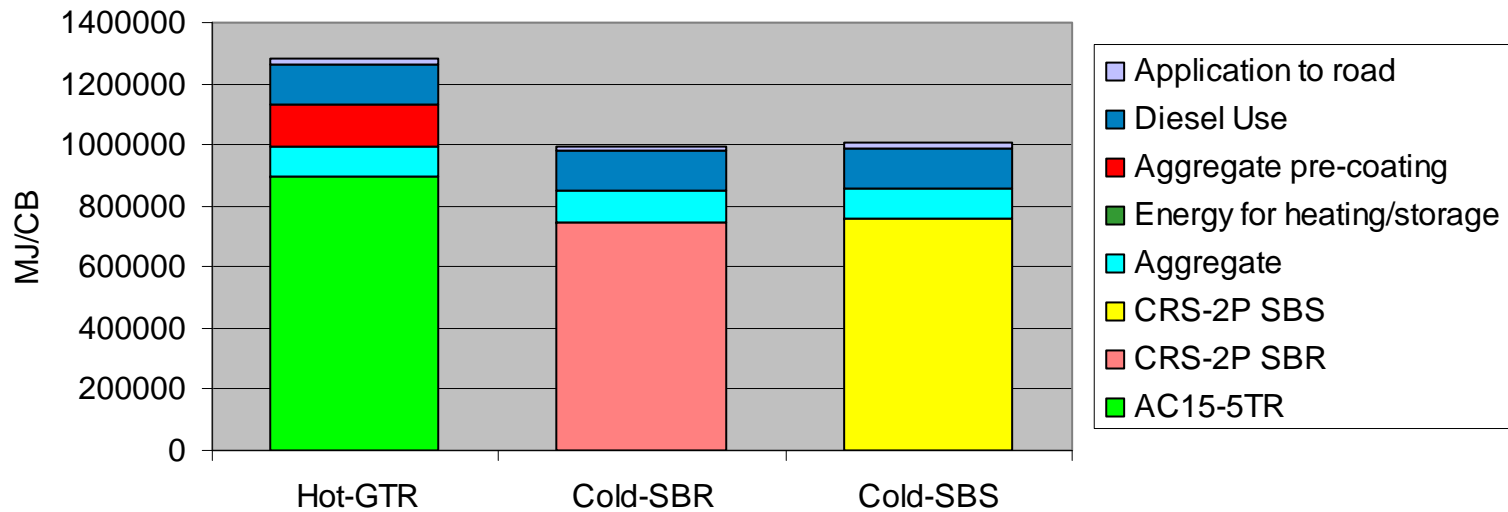
- **Hot Chip Seal, polymer-modified non-emulsified with ground tire rubber (AC-15-5TR or AC-20-5TR)**

Cold alternative

- **Cold polymer-modified Chip Seal, emulsified asphalt (CRS-2P) using SBR or SBS polymers**

# Energy consumption

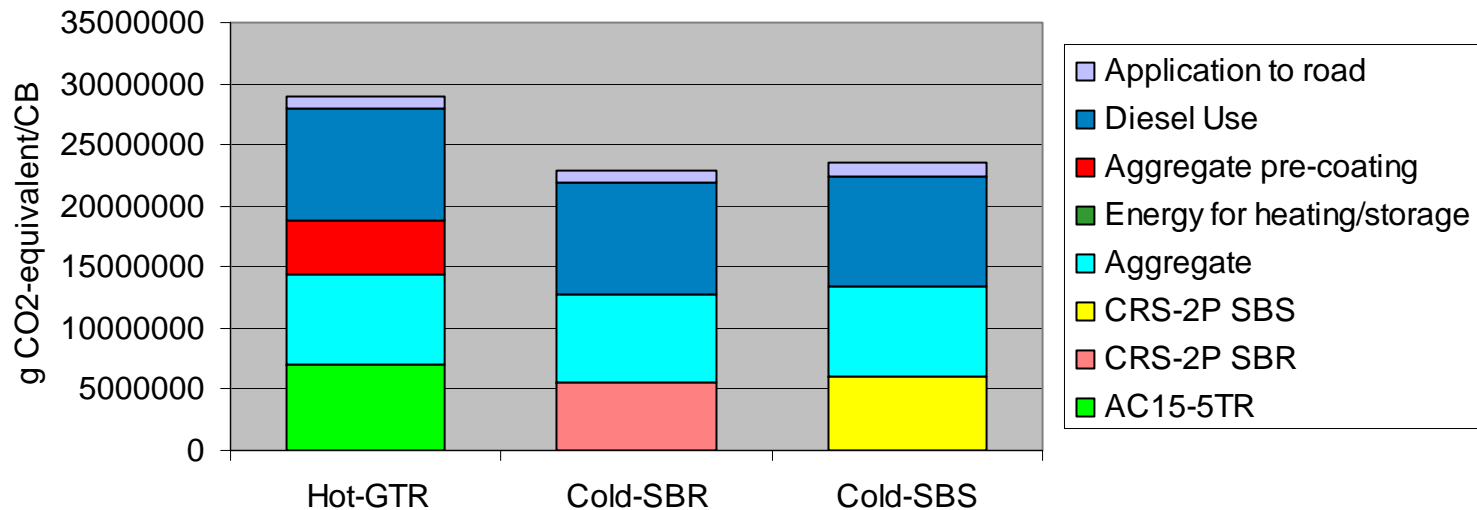
Primary energy consumption



The hot chipseal product uses the most energy due to the higher asphalt content and pre-coating of the aggregate.

# Global Warming Potential

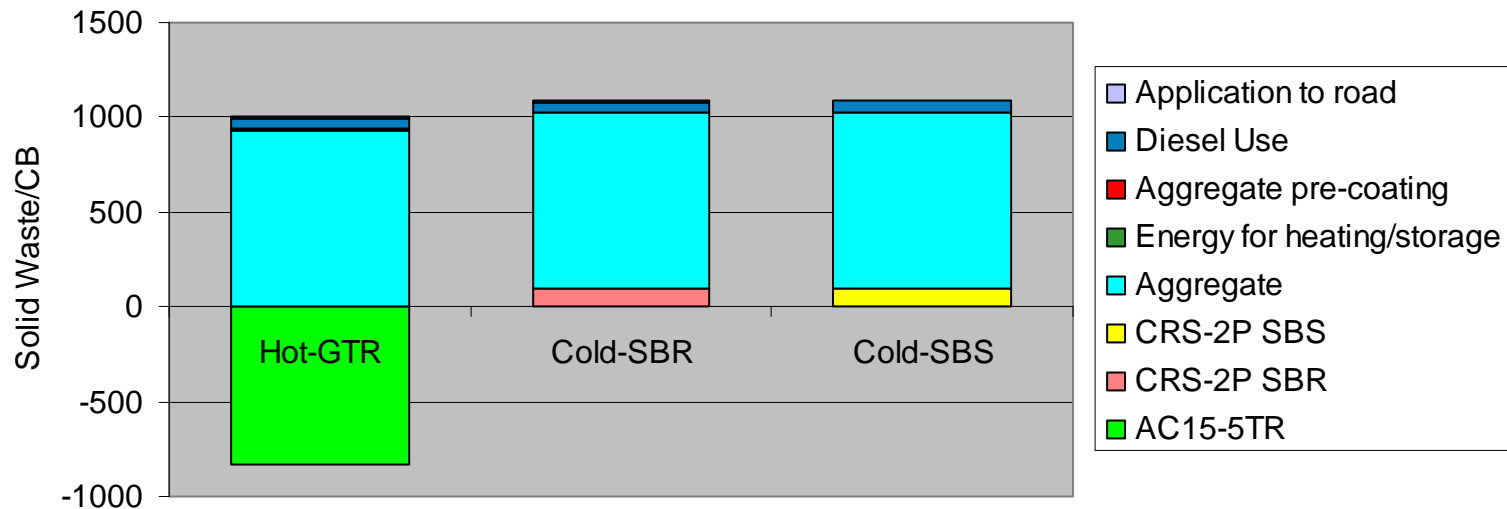
Global Warming Potential



Asphalt used to pre-coat the aggregate and greater asphalt content of the Hot-GTR results in higher global warming potential.

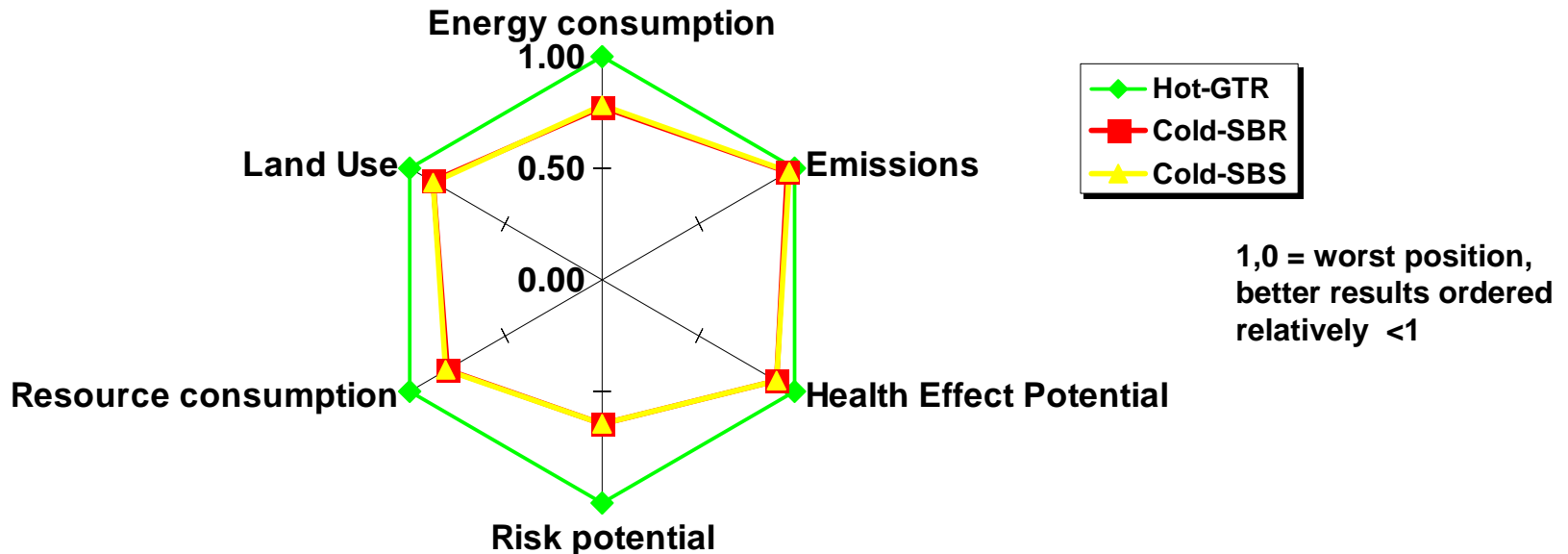
# Solid Waste Emissions

## Solid Waste



Solid waste emissions are primarily from aggregate quarrying. The ground tire rubber alternative has the advantage of recycling material that would otherwise be solid waste, but this is outweighed by the higher impacts in other environmental categories.

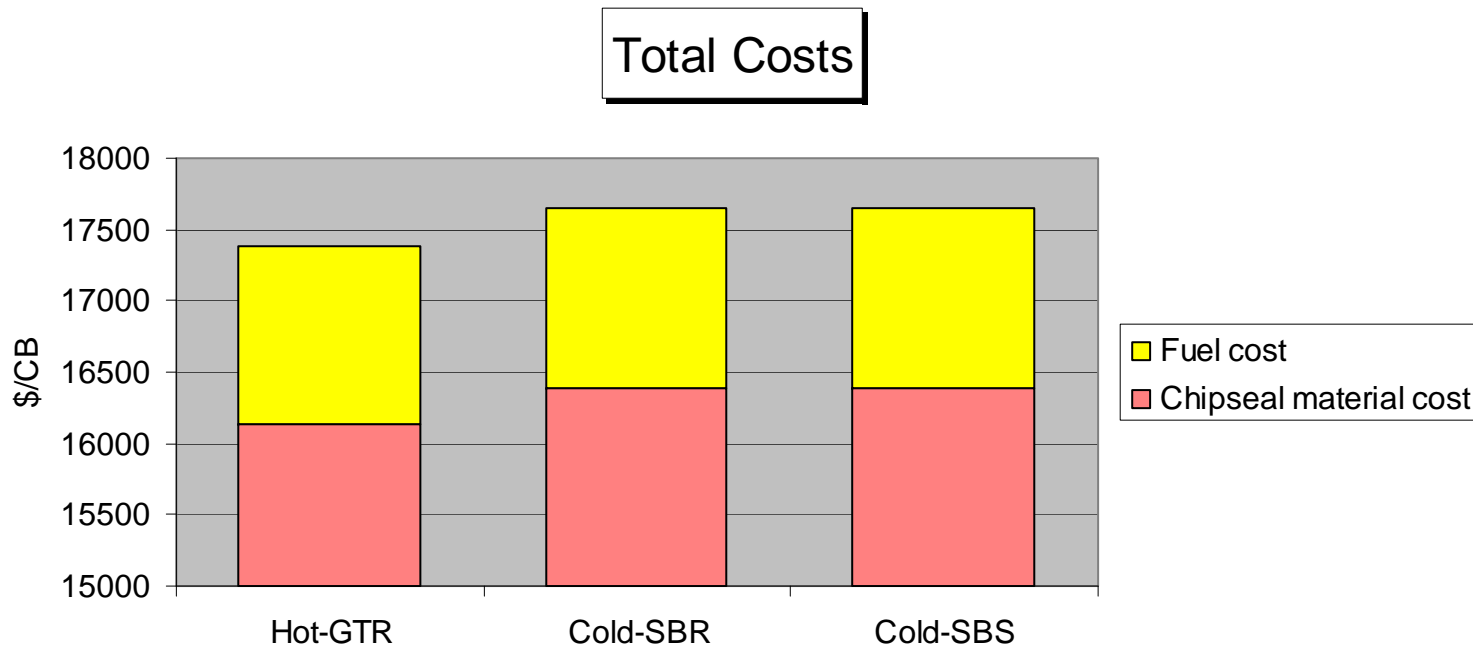
# Ecological Fingerprint



The Cold Chip Seal alternatives have lower overall environmental impact in all categories because:

- they contain less asphalt and do not require pre-coating of the aggregate – meaning less emissions, resource and energy consumption
- they are applied at much lower temperatures, improving application safety and energy usage

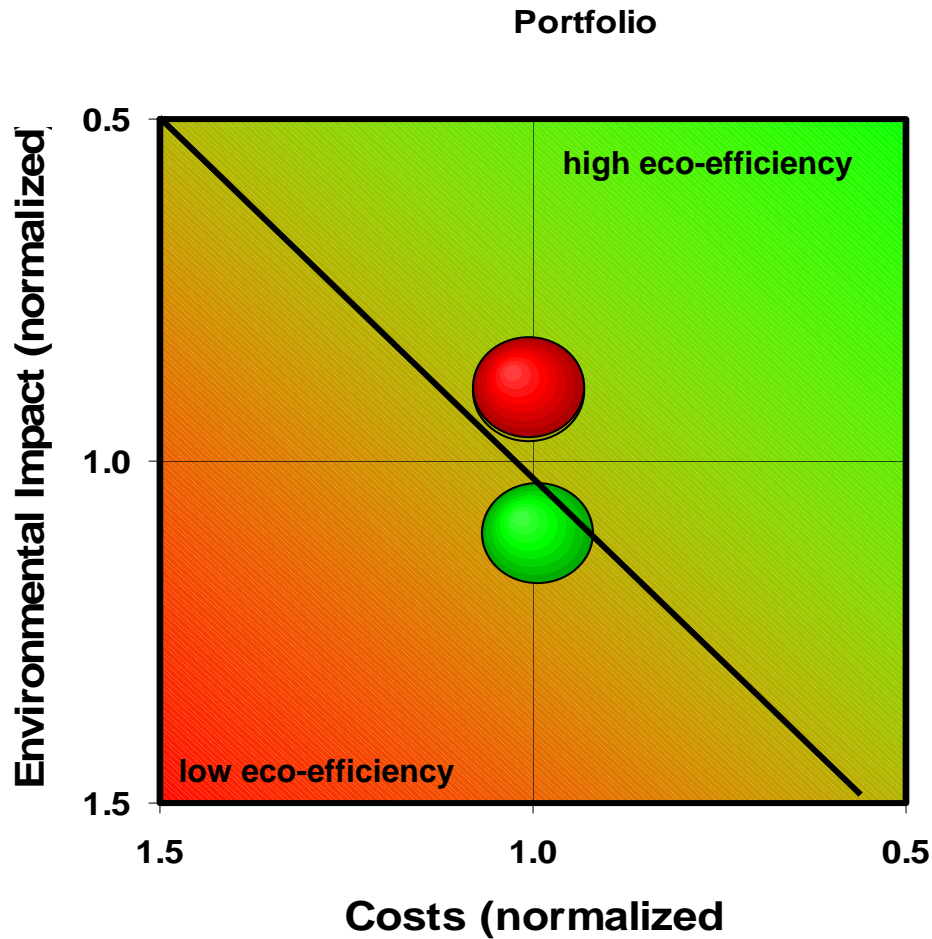
# Application Costs



The hot chipseal is slightly less expensive than the cold chipseal alternatives.

# Chipseal Eco-efficiency Portfolio

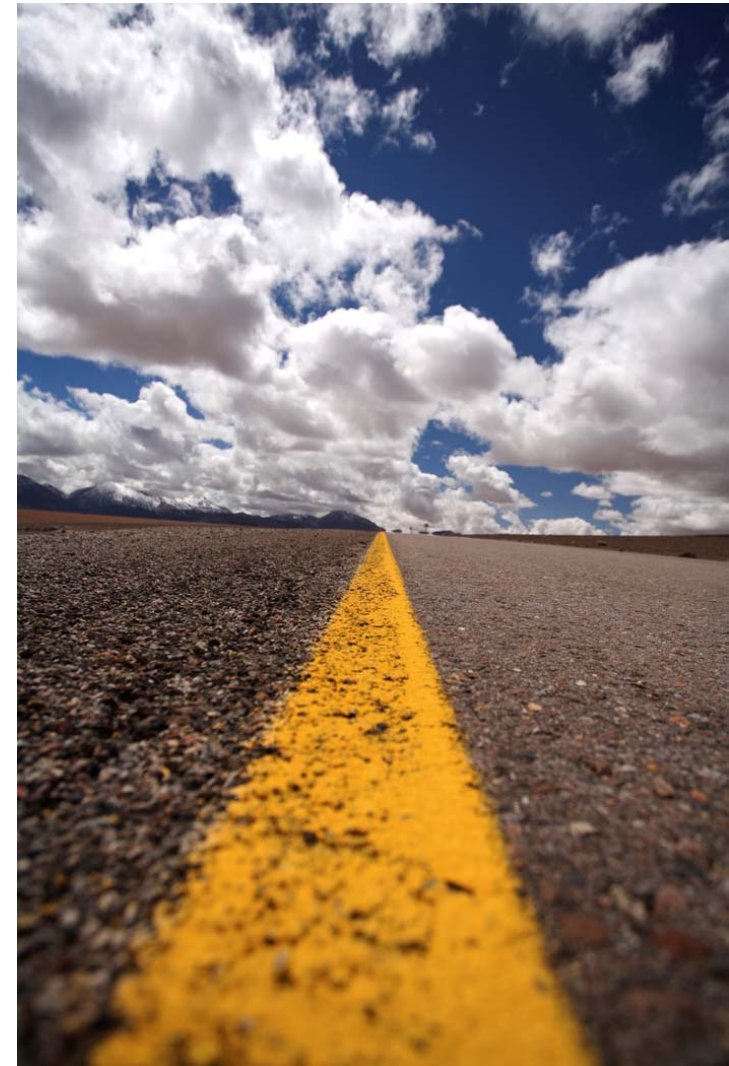
•Resurfacing of a 1-mile, 22-ft wide road stretch, with a lifetime of 7 years, using chipseal



- Hot-GTR
- Cold-SBS
- Cold-SBR

The Cold SBR and SBS alternatives are more eco-efficient.

# The Eco-efficiency of Micro-surfacing vs. Thin Hot Mix Asphalt (HMA) Overlays



# Micro-surfacing vs. Thin Hot Mix Asphalt (HMA) Overlays

Customer benefit  
(CB)

- **Maintenance of 1 lane-mile over a lifetime of 40 years.**

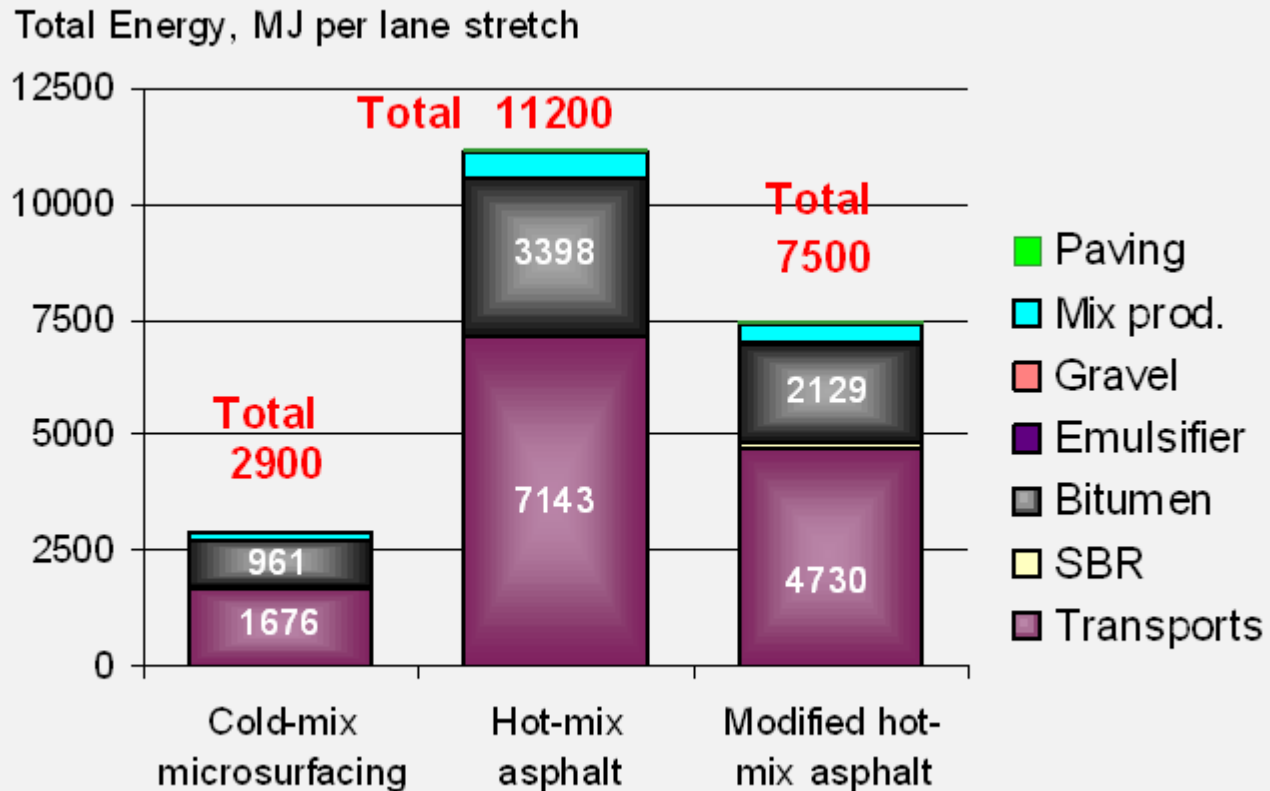
Hot alternative

- **Hot mix asphalt, polymer modified**
- **Hot-mix asphalt (unmodified)**

Cold alternative

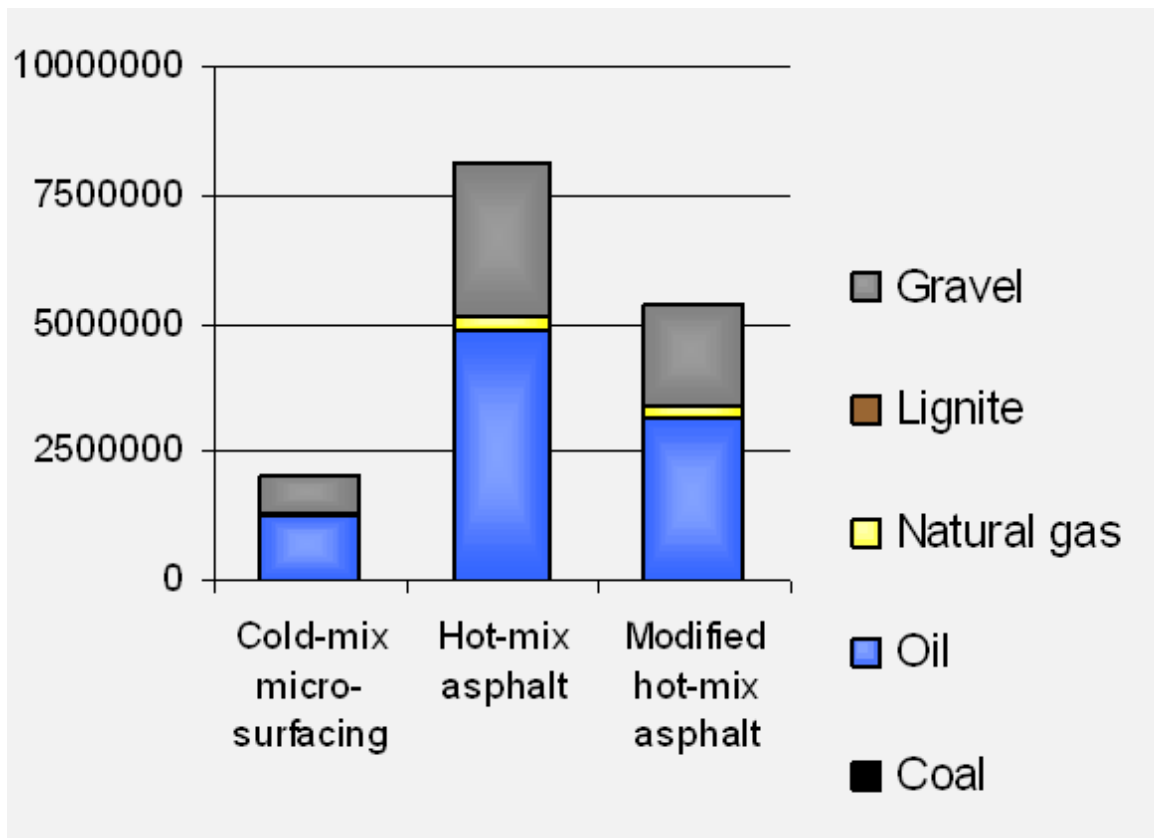
- **Cold-mix asphalt micro-surfacing**

# Energy consumption



# Raw Material Consumption

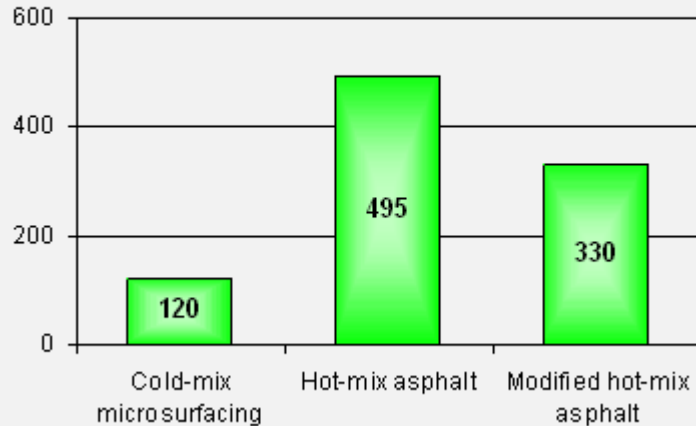
## Resurfacing: Weighted material consumption during a lifespan of 40 years



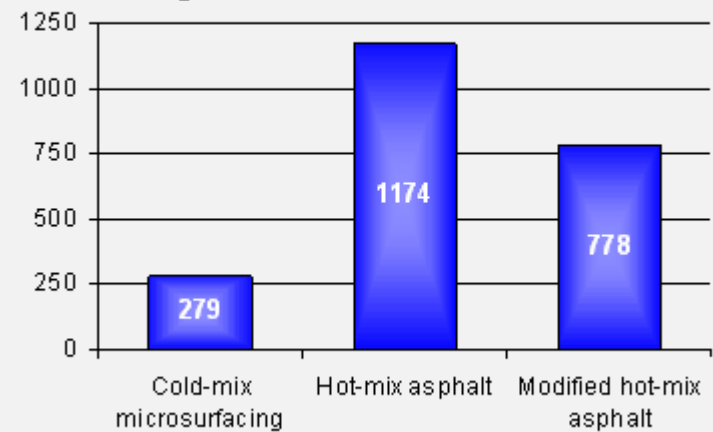
tons per annum and lane mile

# Air Emissions

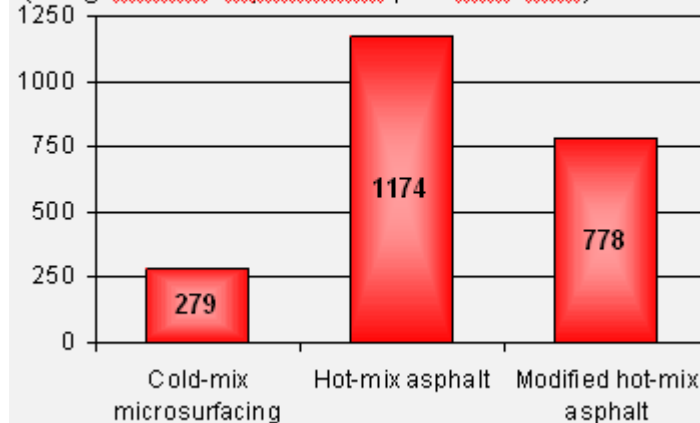
Global warming potential  
(in t CO<sub>2</sub>-equivalents per lane mile)



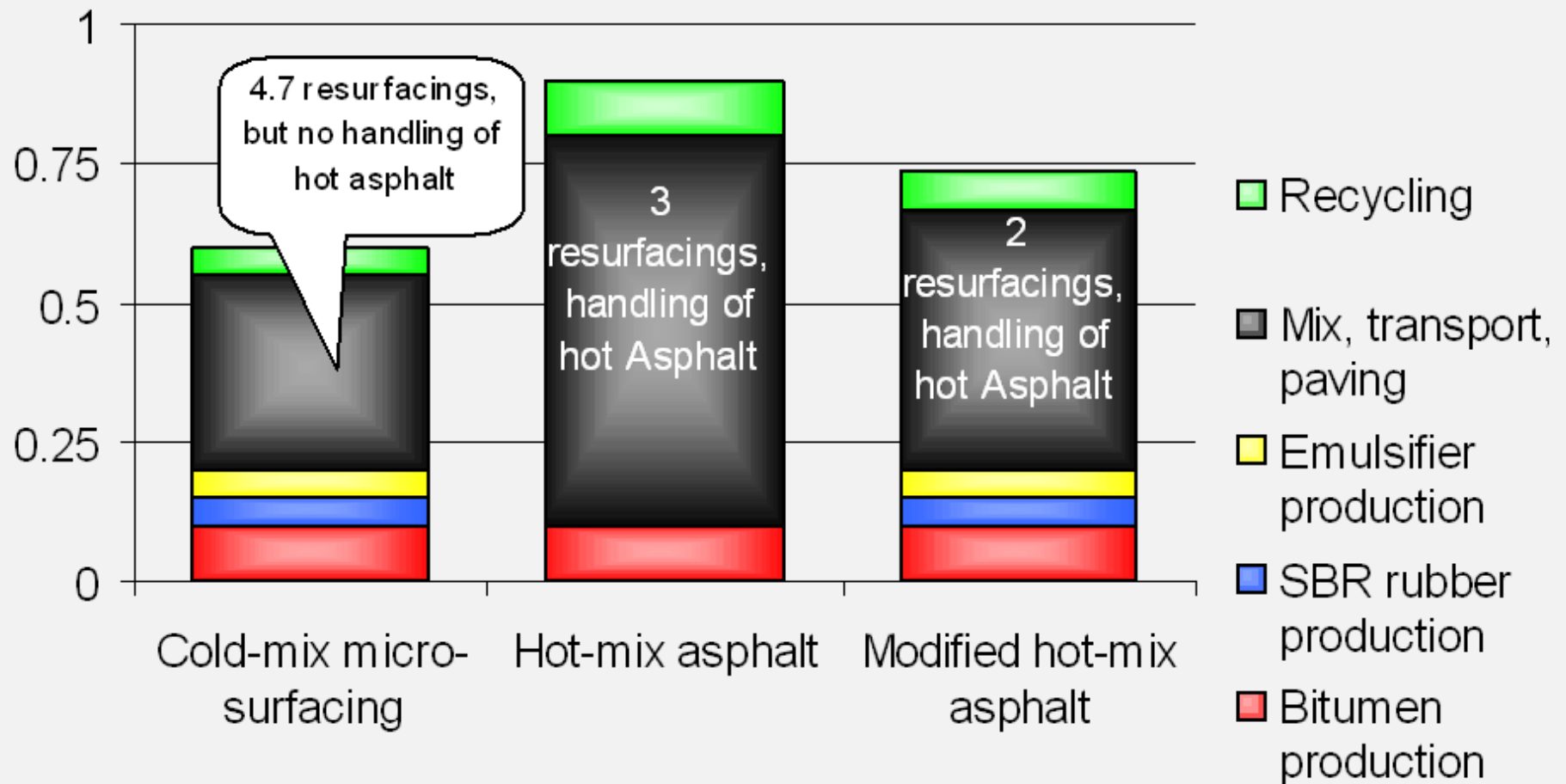
Acidification potential  
(in kg NO<sub>2</sub>-equivalents per lane mile)



Photochemical ozone creation potential  
(in kg ethene-equivalents per lane mile)

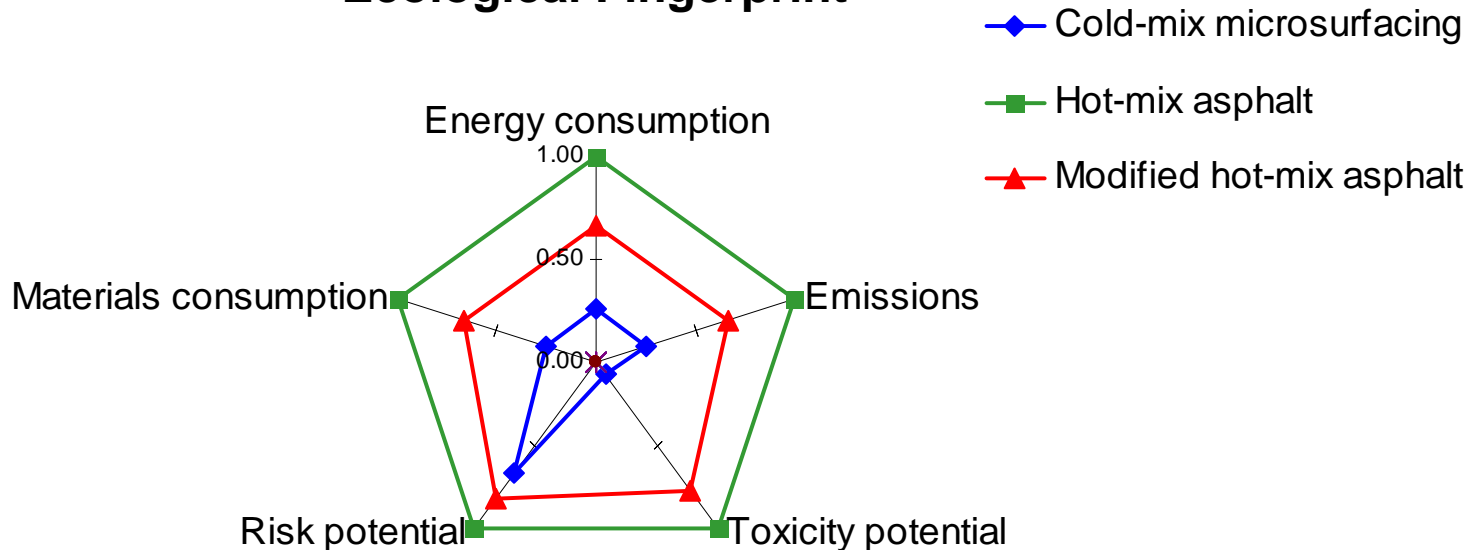


# Risk Potential



# Micro-surfacing vs. Thin Hot Mix Asphalt (HMA) Overlays

## Ecological Fingerprint



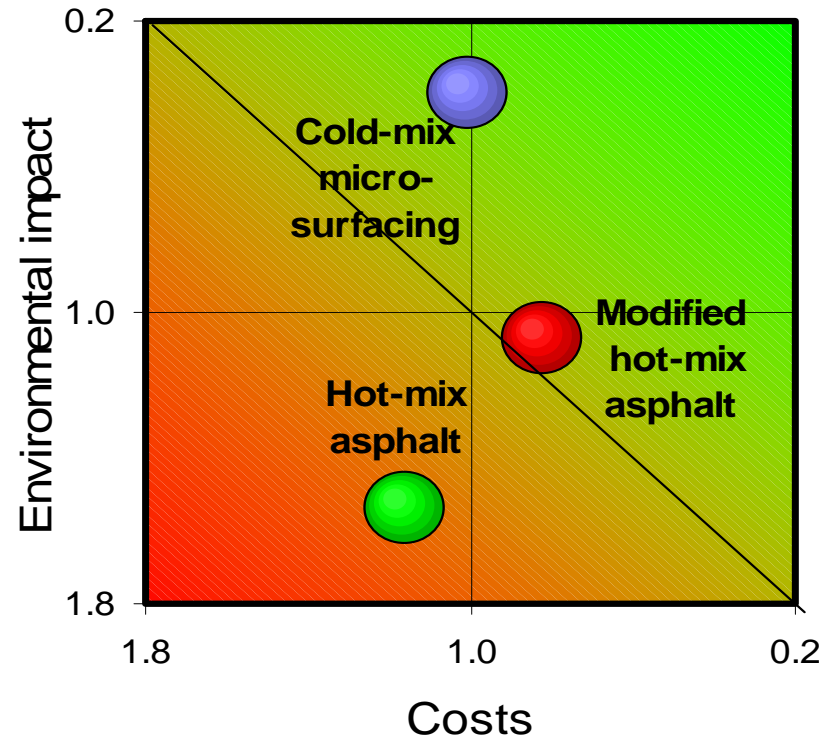
The cold-mix microsurfacing alternatives have lower overall environmental impact in all categories because:

- reduced thickness of the road surface leads to advantages in material consumption, emissions and energy consumption.
- handling less material and the avoidance of (toxic) workplace aerosols during application in street construction leads to a lower overall toxicity (human health) potential.
- cold-mix microsurfacing has a lower risk potential because no hot bitumen is used during application on the street surface

# Micro-surfacing vs. Thin Hot Mix Asphalt (HMA) Overlays

• Maintenance of 1 lane-mile over a lifetime of 40 years.

### Eco-efficiency Portfolio



Alternatives considered

- Cold-mix micro-surfacing
- Modified hot-mix asphalt
- Hot-mix asphalt



Successful sustainable  
development programs require  
strong partners



# Contact Information



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[http://www.basf.com/group/sustainability\\_en/index](http://www.basf.com/group/sustainability_en/index)

