# The Eco-efficiency of Pavement Preservation Technologies

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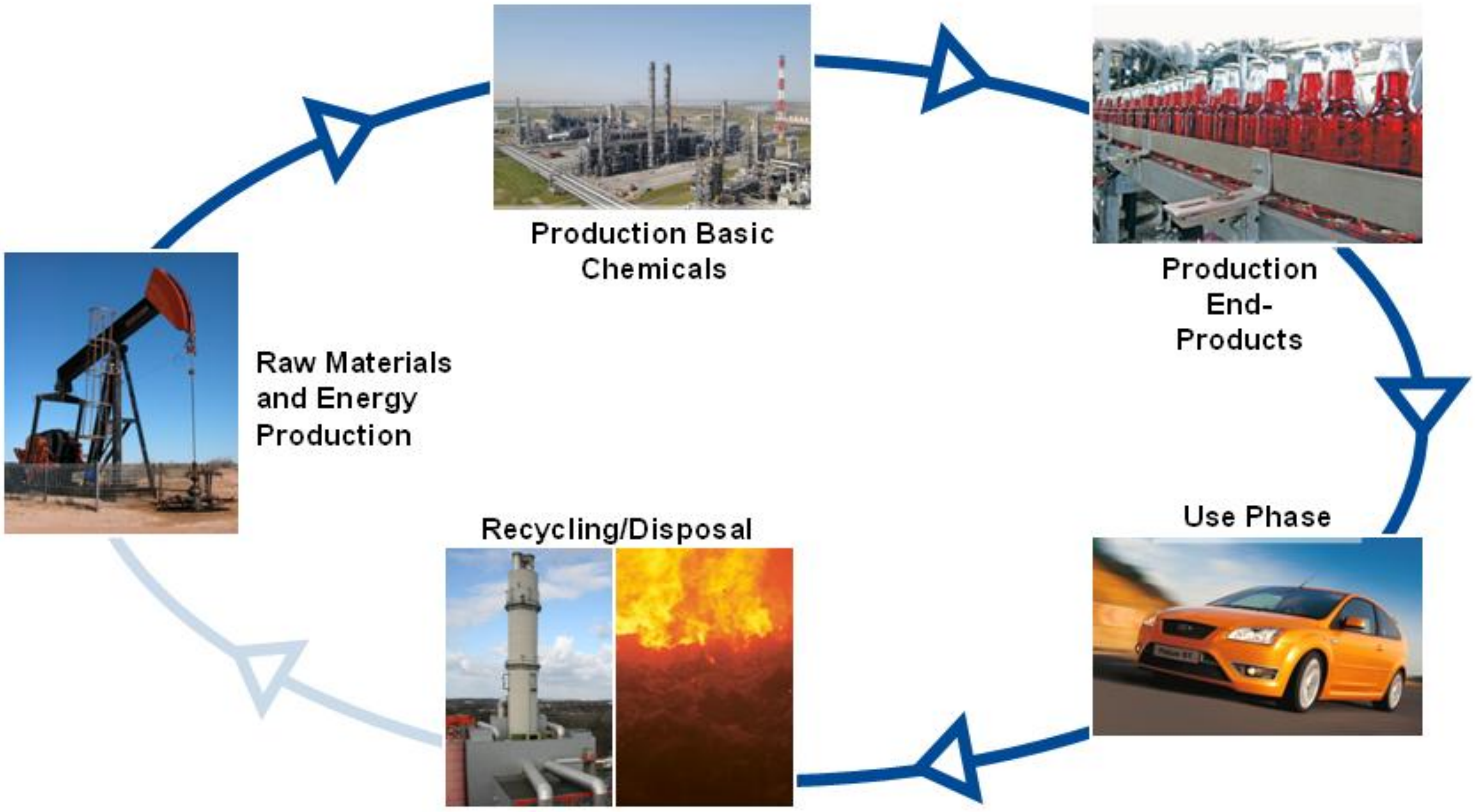
# Defining Sustainability

# Measuring Sustainability

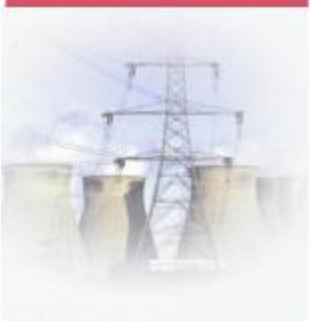

Being able to measure sustainability is critical to its successful integration into business strategy and strategic decision making

# Sustainability: A life cycle approach



# The Eco-efficiency Analysis

Energy



Raw Materials

Land Use

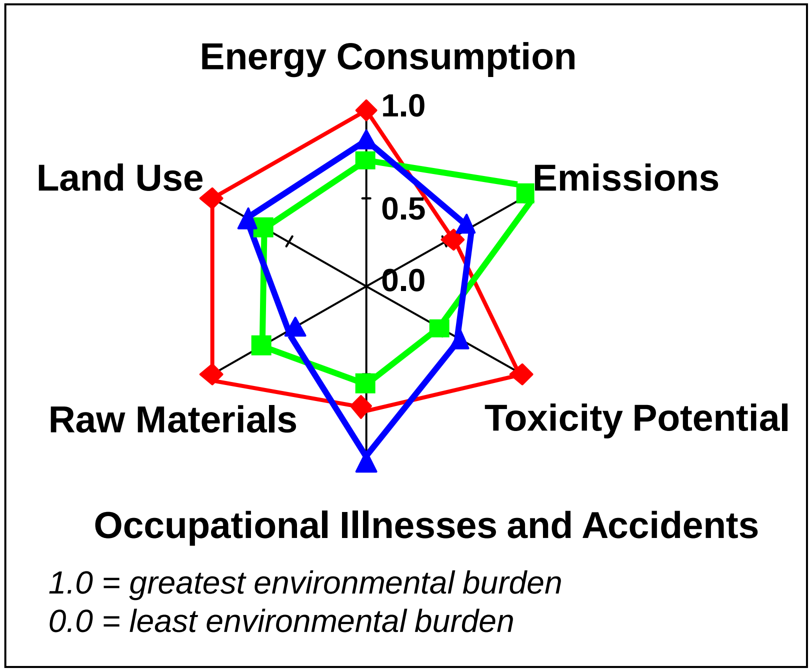
Risk

Toxicity Potential

Emissions

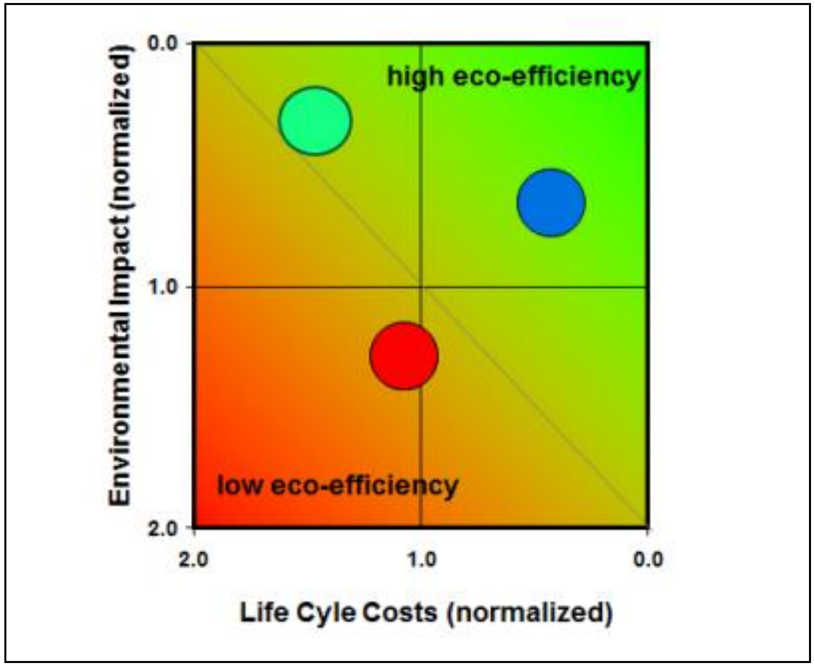
3rd party validated life cycle assessment methodology

## Environmental Fingerprint

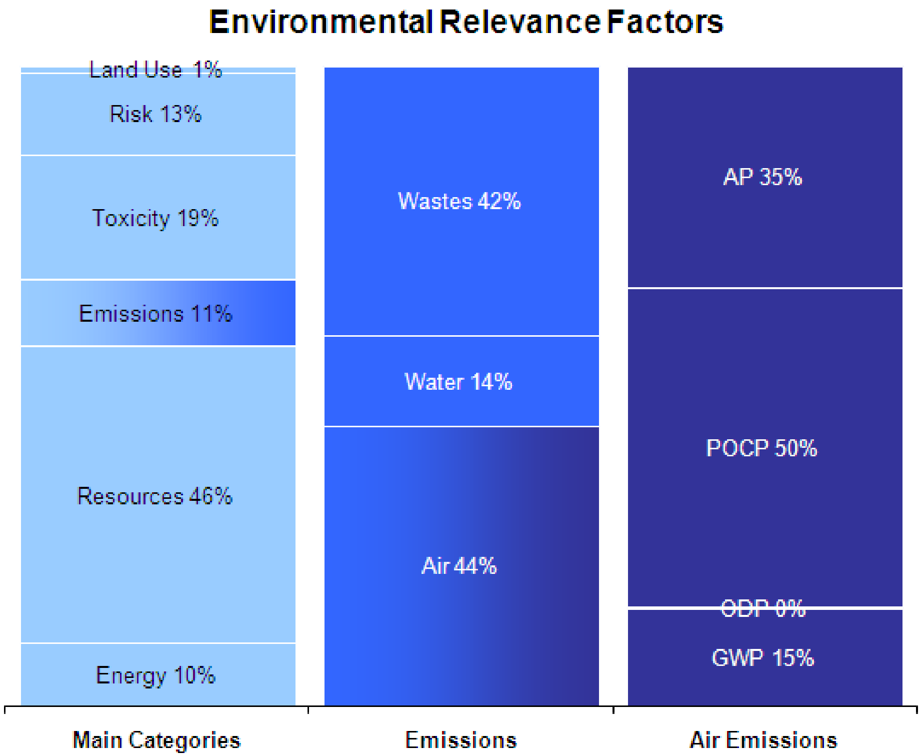


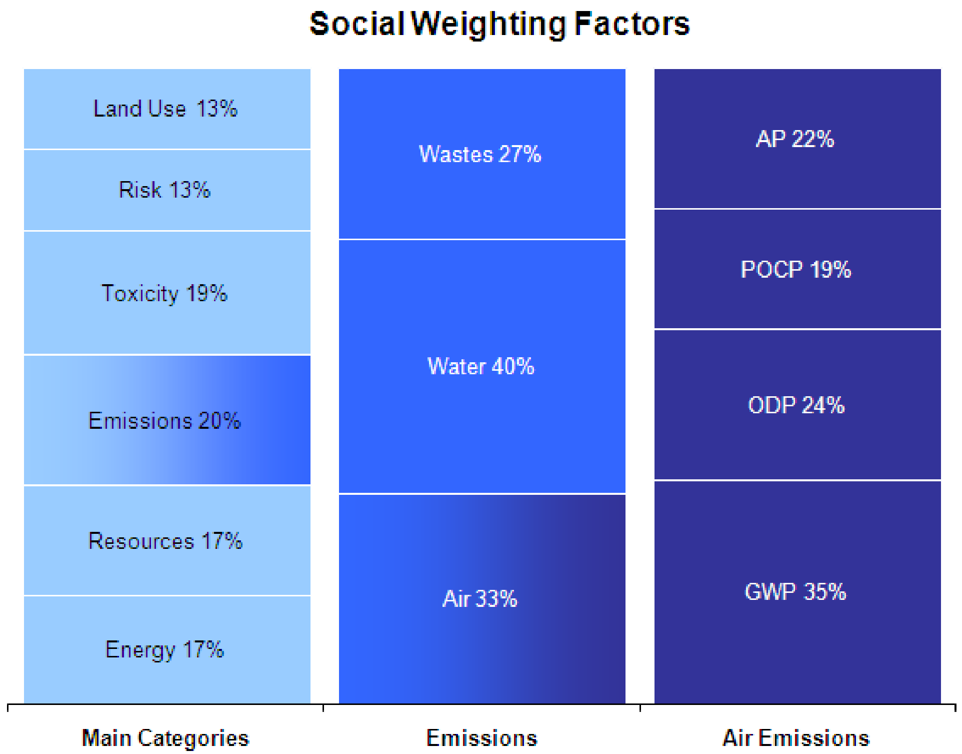

Life cycle data is gathered in six environmental categories for each alternative and depicted on an environmental fingerprint. The data is then weighted, aggregated and normalized to obtain an overall environmental impact.

## Eco-efficiency Portfolio




Eco-efficiency portfolio balances life cycle environmental impacts with life cycle cost data. It reflects a comparative assessment of the relative eco-efficiencies of various alternatives.




What does the emission (or energy consumption) contribute to the total emissions (or energy consumption) in the region considered ?

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

# Sustainability Metrics Support Decision Making

## STRATEGIC DECISIONS

- Investment decisions
- Technology decisions
- Site decisions
- Evaluate product portfolio

## MARKETING, CUSTOMERS

- Demonstration of product advantages
- Improved customer relations
- Product differentiation
- Better understand competitive advantage
- Provides needed benchmarks

## RESEARCH AND DEVELOPMENT

- Quantification of the most important factors
- Drive sustainable products and processes
- Drive production/process improvements

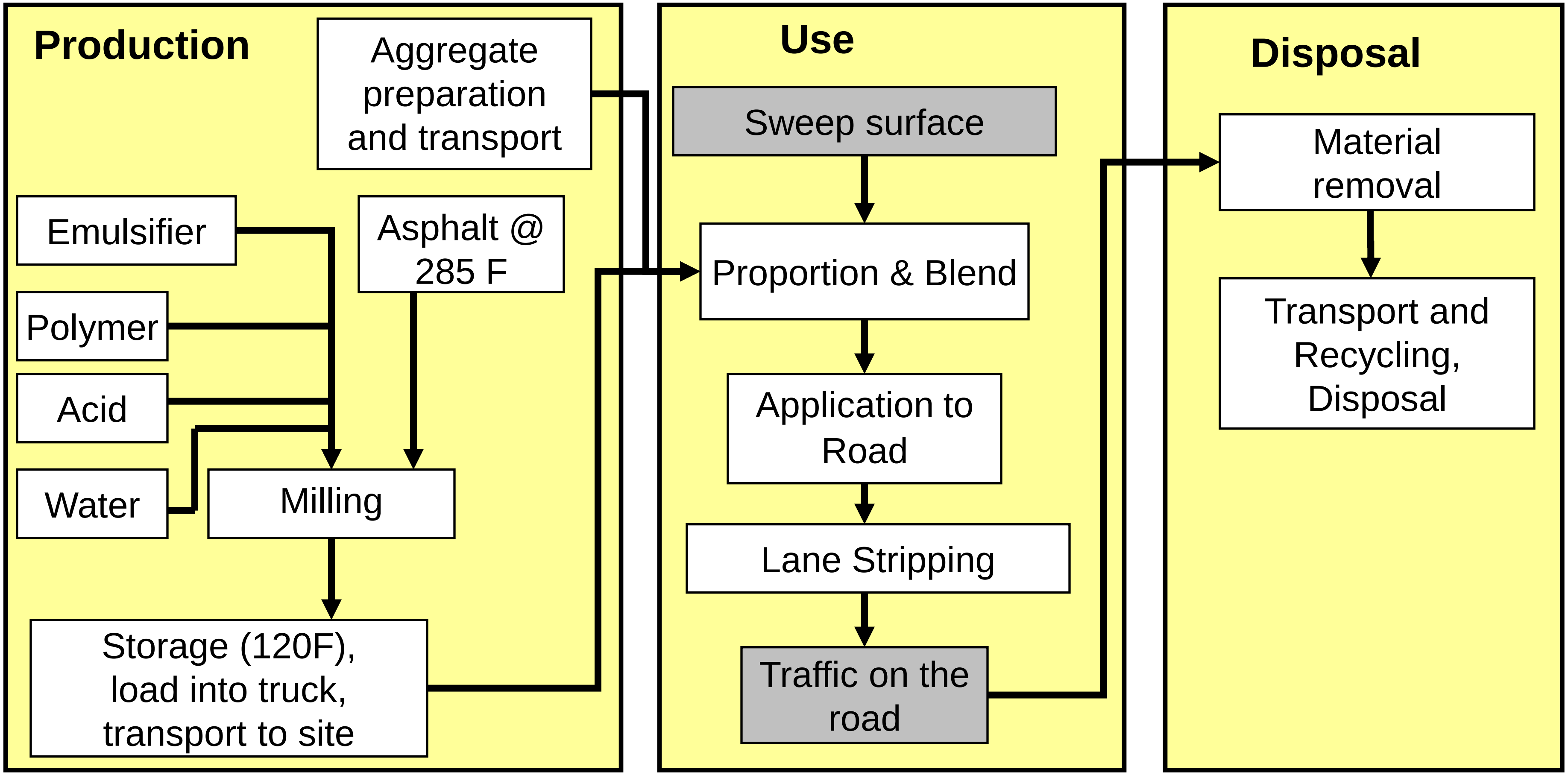
## STAKEHOLDER AND GOVERNMENT DIALOGUE

- Communication with authorities
- Demonstration of sustainability
- Government “approvals”
- Provides needed benchmarks

# The Eco-efficiency of Micro surfacing

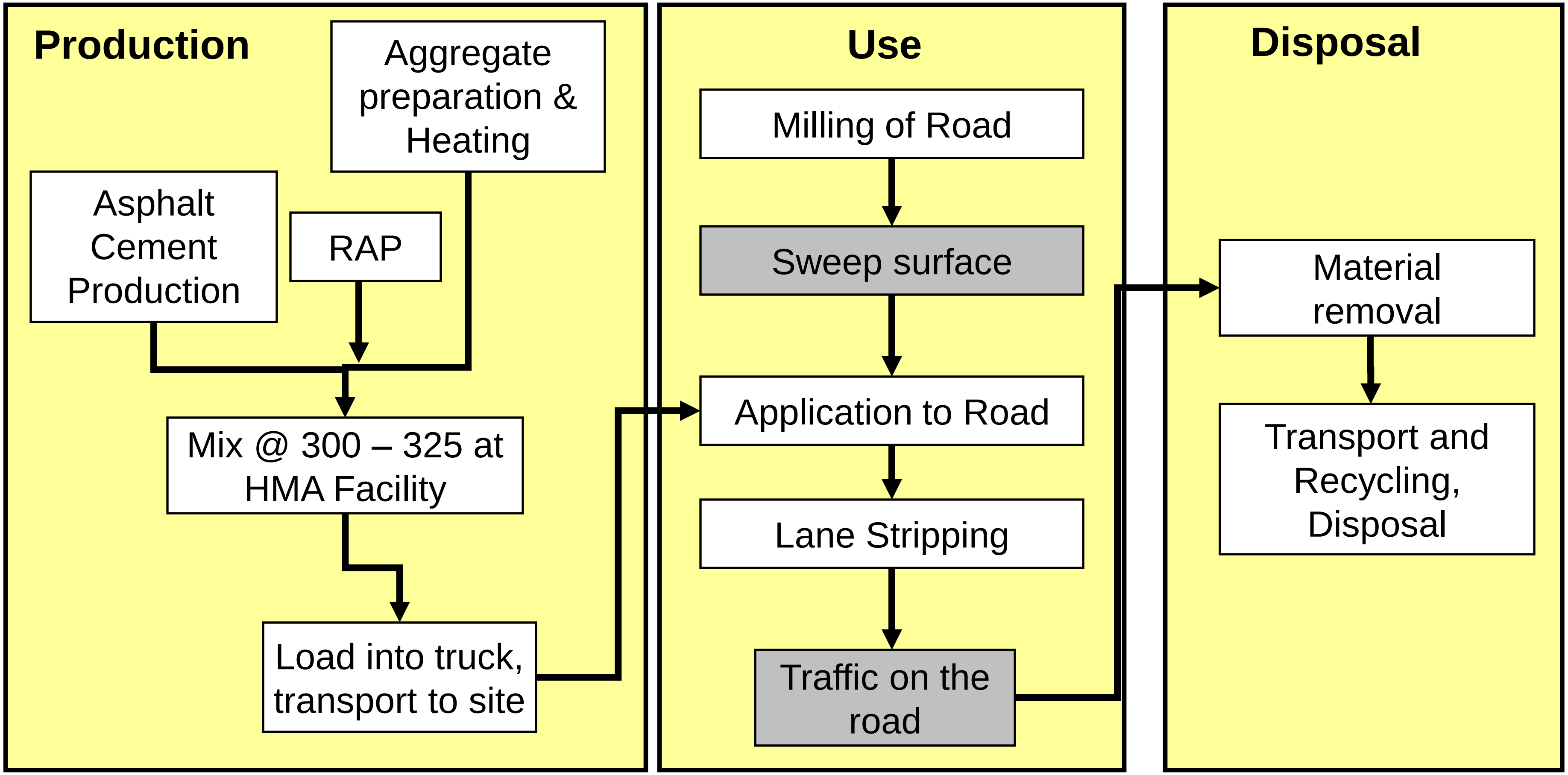
A collaborative project by BASF and Vance Brothers

# System Boundaries – Micro surfacing
# Polymer modified asphalt emulsion w/ SBR




*Grey boxes are not considered, since they are the same for all alternatives.*

# System Boundaries – Polymer Modified Hot Mix Overlay (2“ Mill and Fill)

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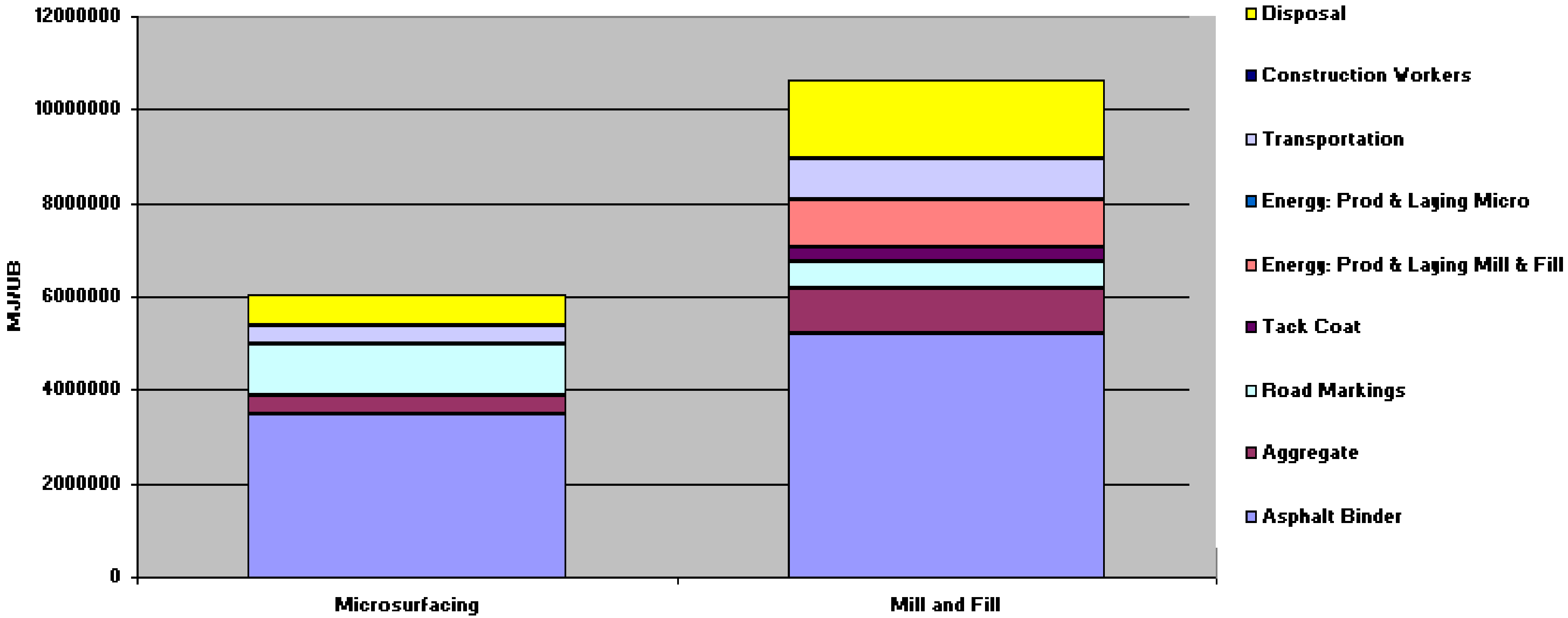
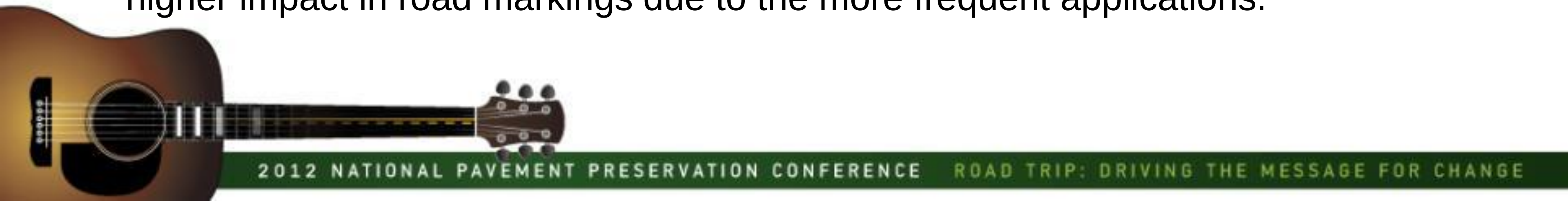
# Key Input Data

| CUSTOMER BENEFIT: | | | |
|---|---|---|---|
| Road Surface | | **Microsurfacing** | **Mill and Fill** |
| Length | mi | | |
| Width | ft | 12 | 12 |
| Area | sq. yard | 7040 | 7040 |
| | sq. meter | 5886 | 5886 |
| Life Expectancy of Road | years | 40 | 40 |
| Life Expectancy of Technology | years | 6 | 11 |
| Number of Road Applications over Life Cycle | | 7 | 4 |
| Duration to apply Technology | days | 0.50 | 2 |
| RAP | % | | 10% |
| Financial Discount Rate | % | 4.80% | |
| Social Discount Rate | % | 6.00% | |
| Highway Rental Fee | $/lane-mile-day | $5,000.00 | |
| Lane Stripping | $/mile | $4,455.00 | |
| Work Zone Injuries - Accidents | #/day-mile | 0.00552 | |
| Work Zone Fatalities | #/day-mile | 0.00009 | |

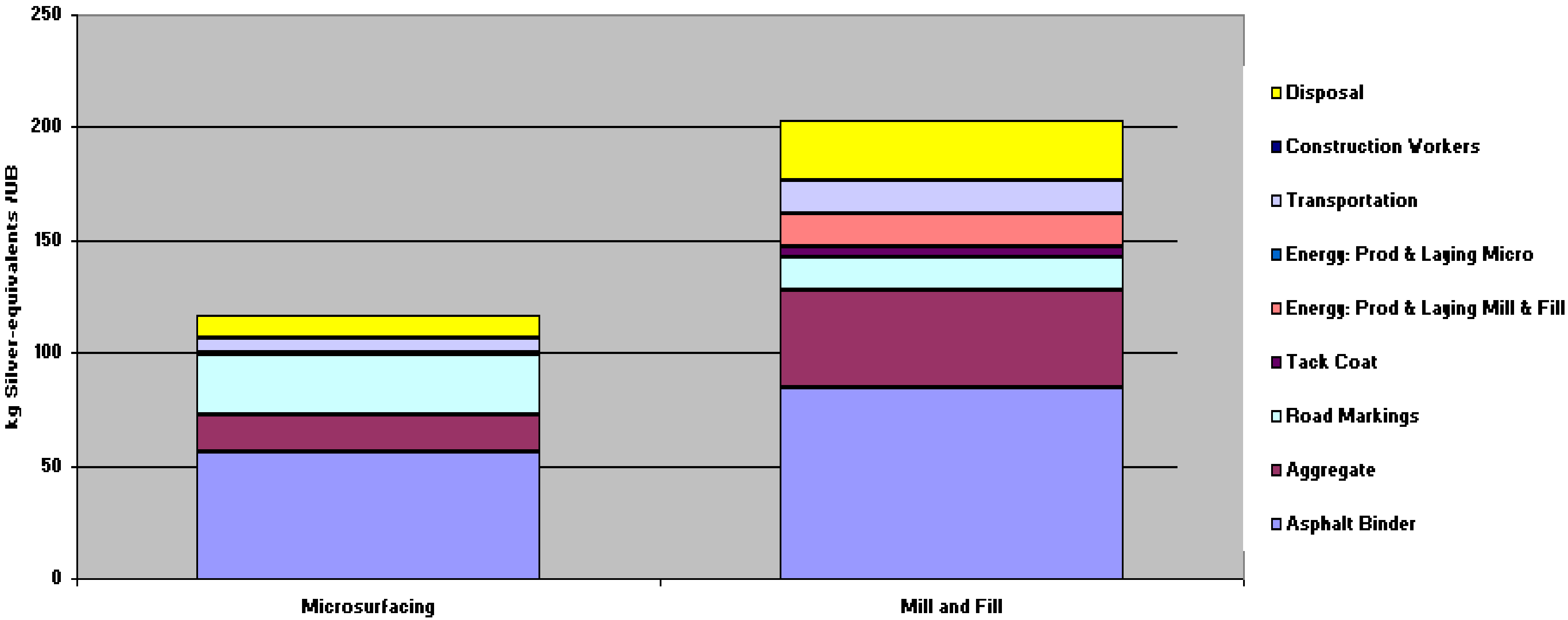
# Environmental Impact
## Energy Consumption




Hotter production and application temperatures for Mill & Fill (HMA) as well as the increased fuel requirements for shipping larger amounts of material to and from the job site contribute to Mill & Fill having a higher energy impact. Micro surfacing has a higher impact in road markings due to the more frequent applications.

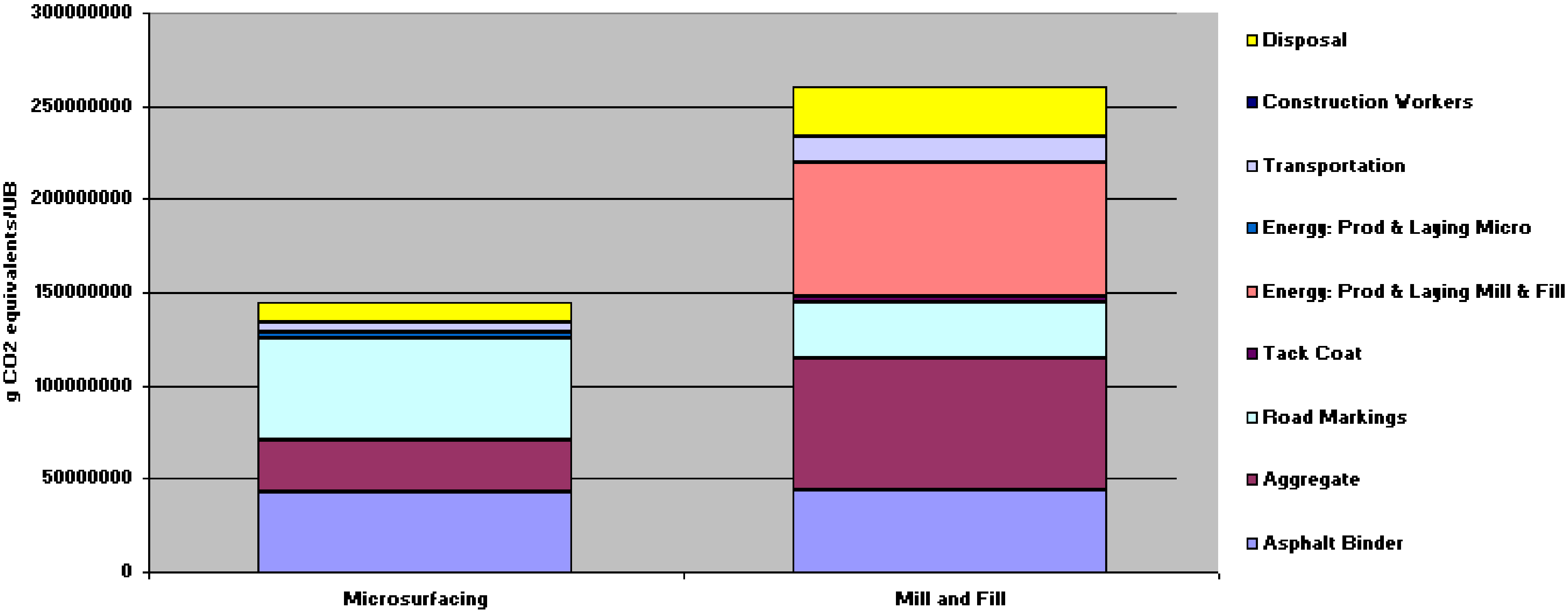


# Environmental Impact
## Resource Consumption



# Environmental Impact

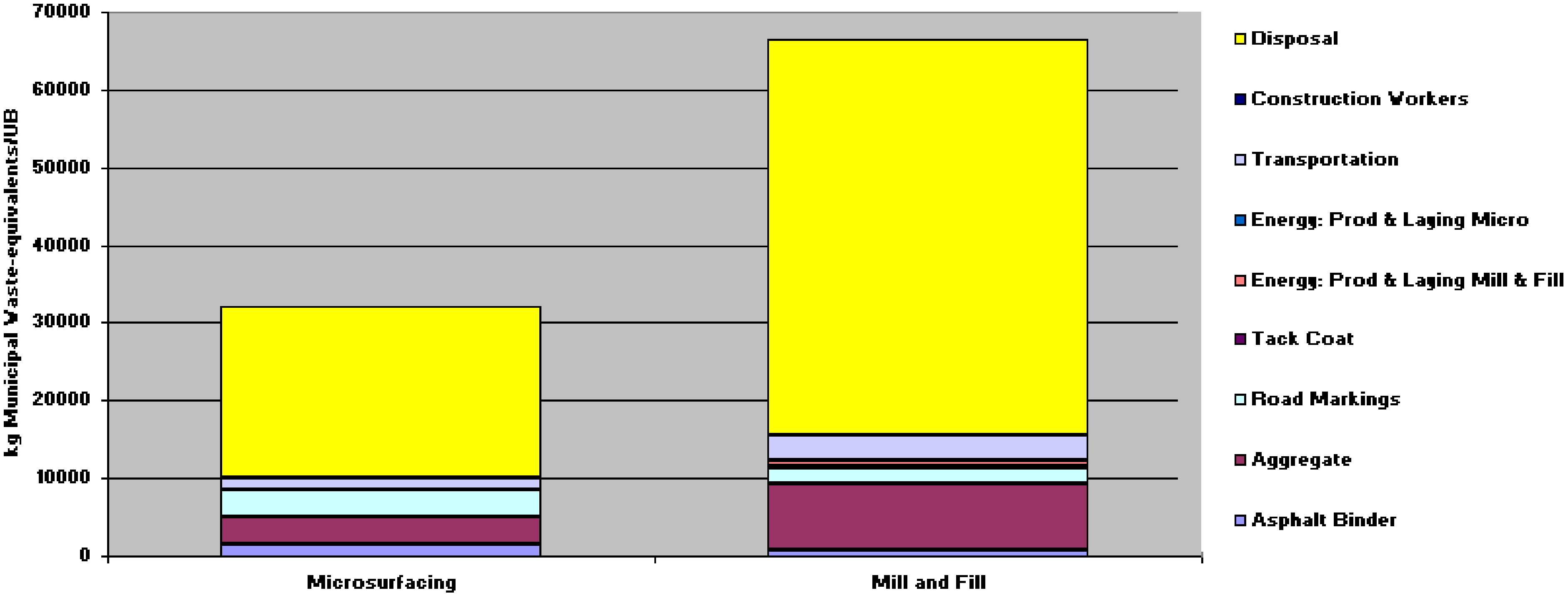
## Air Emissions – Global Warming Potential



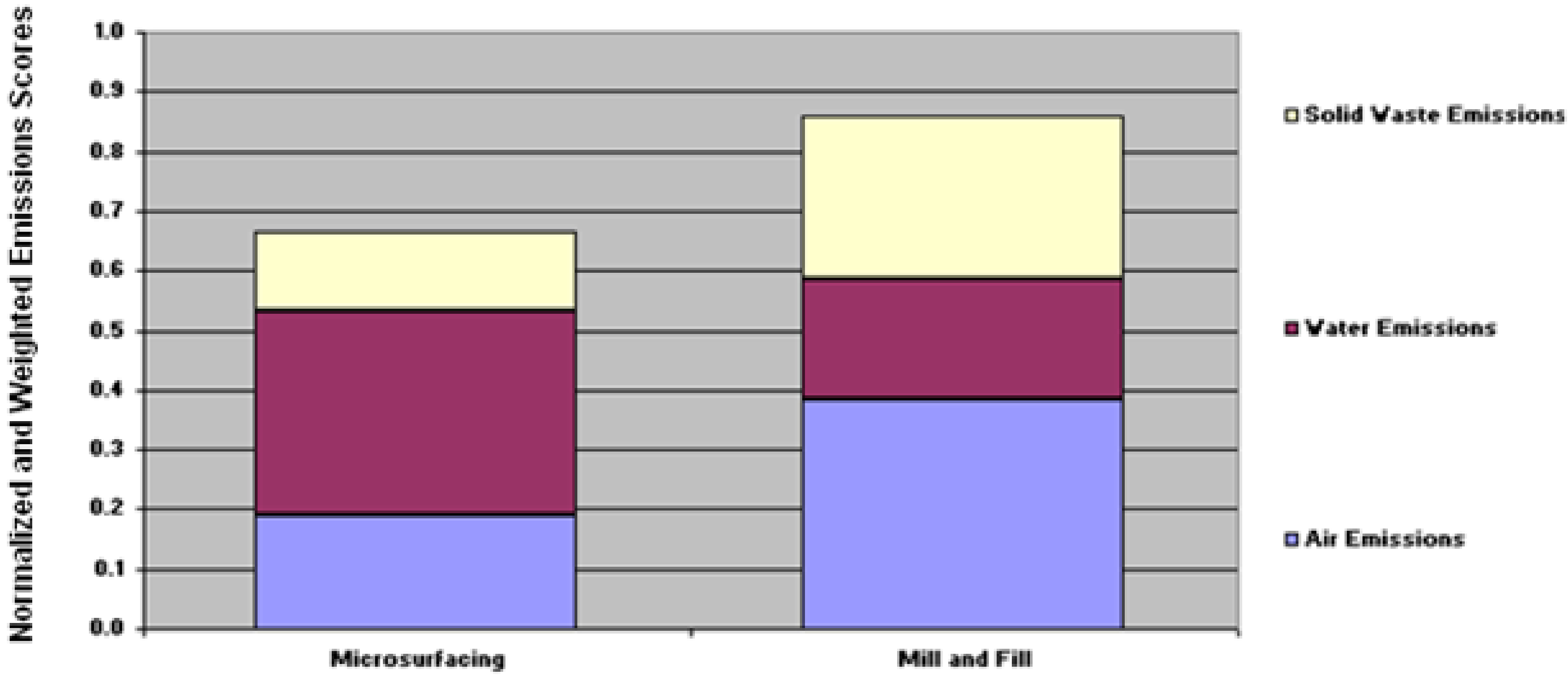

Activities related to the transportation and milling of the aggregate as well as the energy consumed during the production, transportation and application of the asphalt had the highest impact on the GWP for the alternatives. $CO_2$ emissions from the manufacturing / application of the road markings also is a significant contributor.

# Environmental Impact

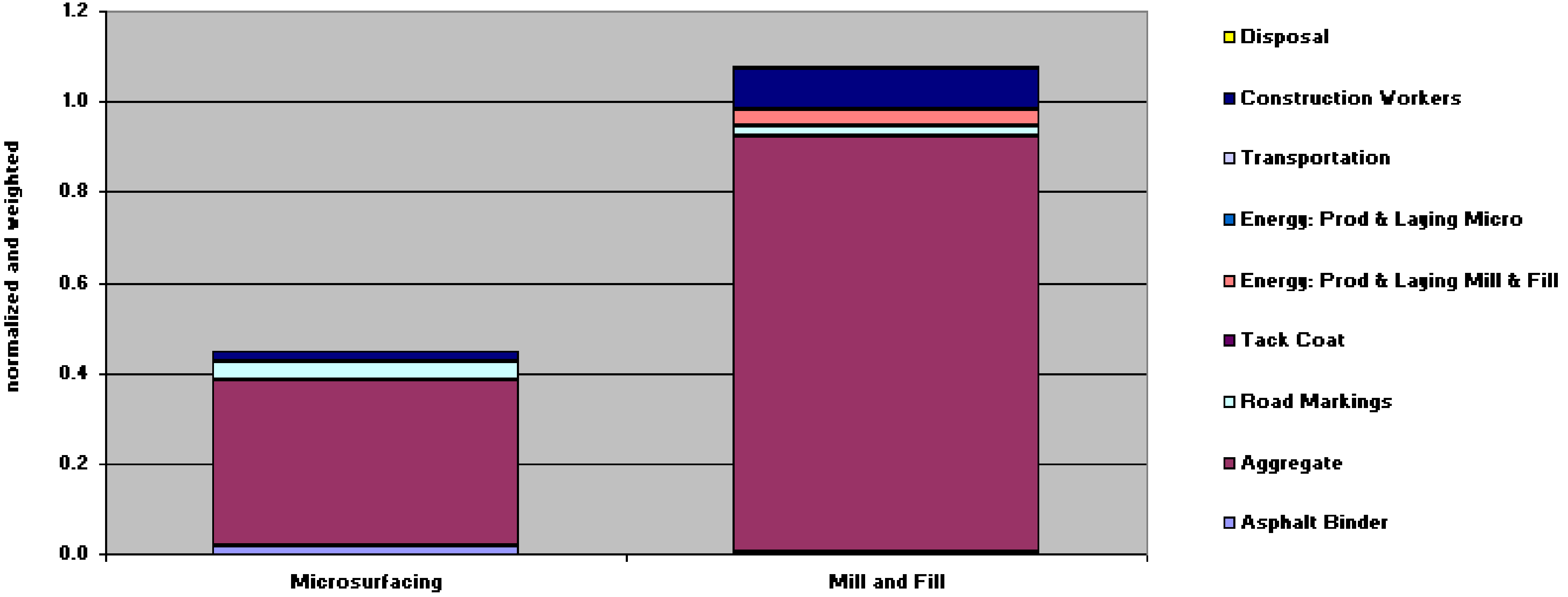
## Solid Waste Emissions




# Environmental Impact
## Overall Emissions

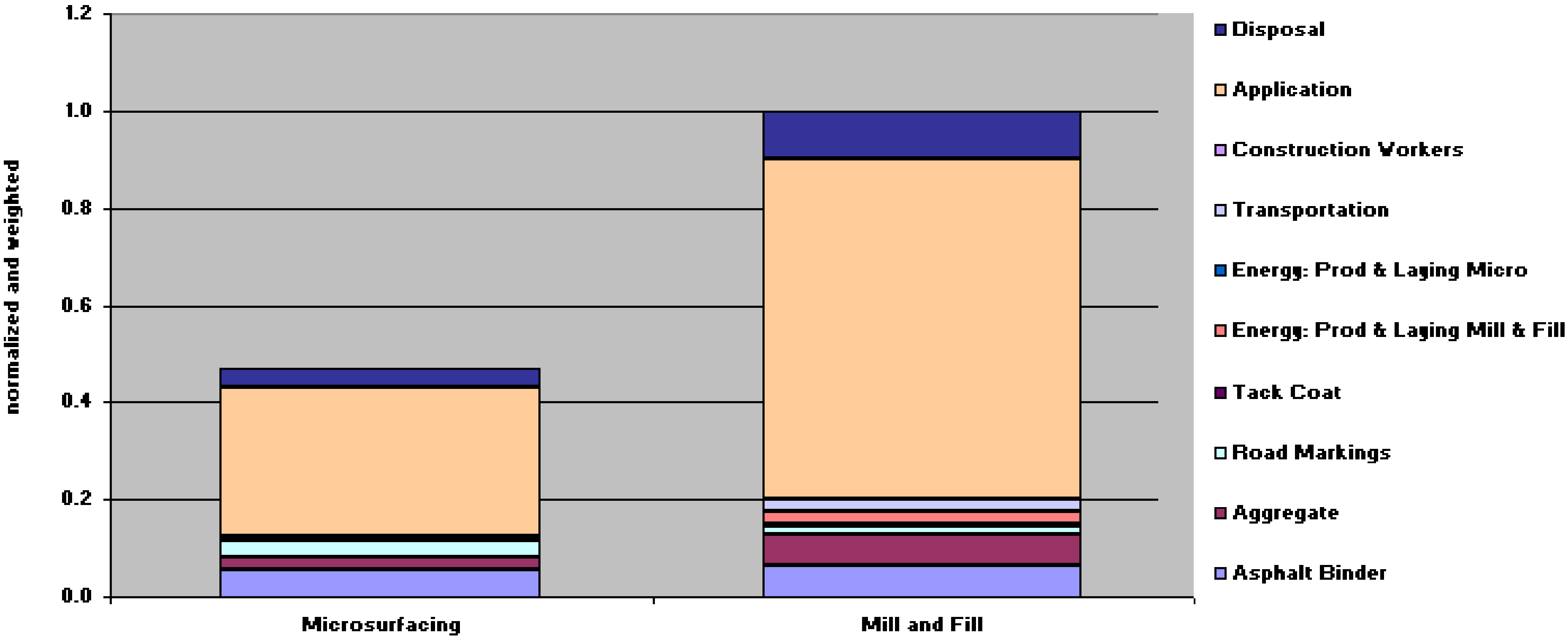


# Risk Potential : Occupational Illnesses & Accidents



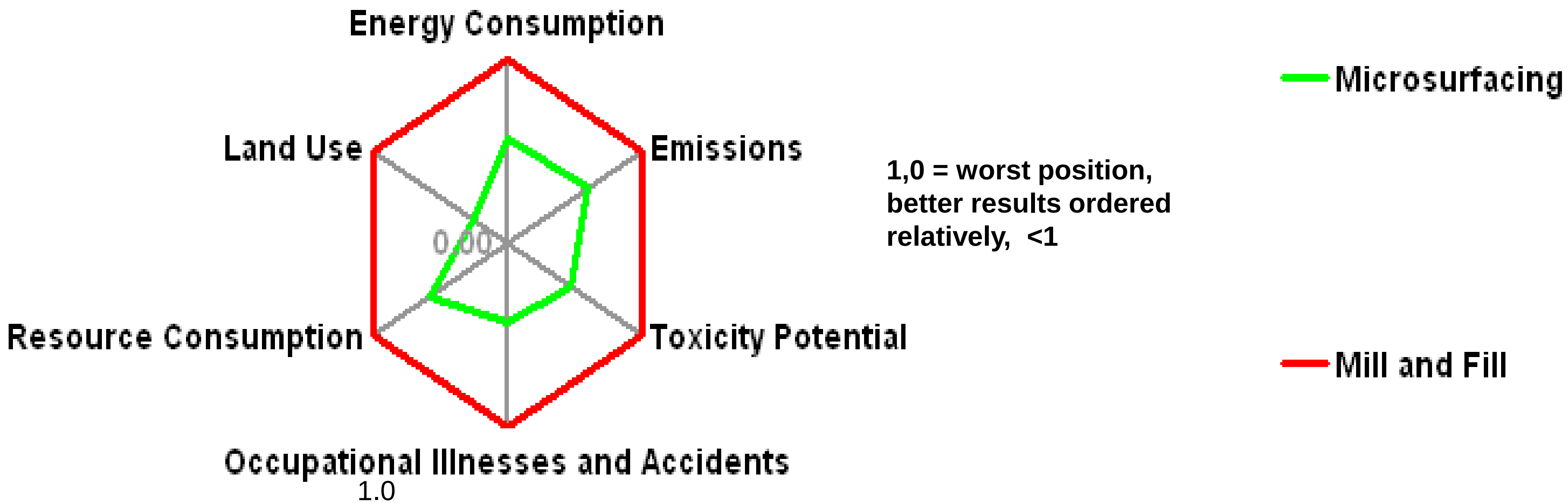

Aggregate, the single largest resource for each alternative, contributes the highest risk potential for occupational illnesses and accidents. The longer construction time required for the Mill and Fill alternative exposes the construction workers to a higher risk of construction related injuries and fatalities.

# Toxicity Potential: Modules




The toxicity potential of the materials and activities related to the application of the asphalt material to the road for each alternative has the highest impact.

# Environmental Fingerprint

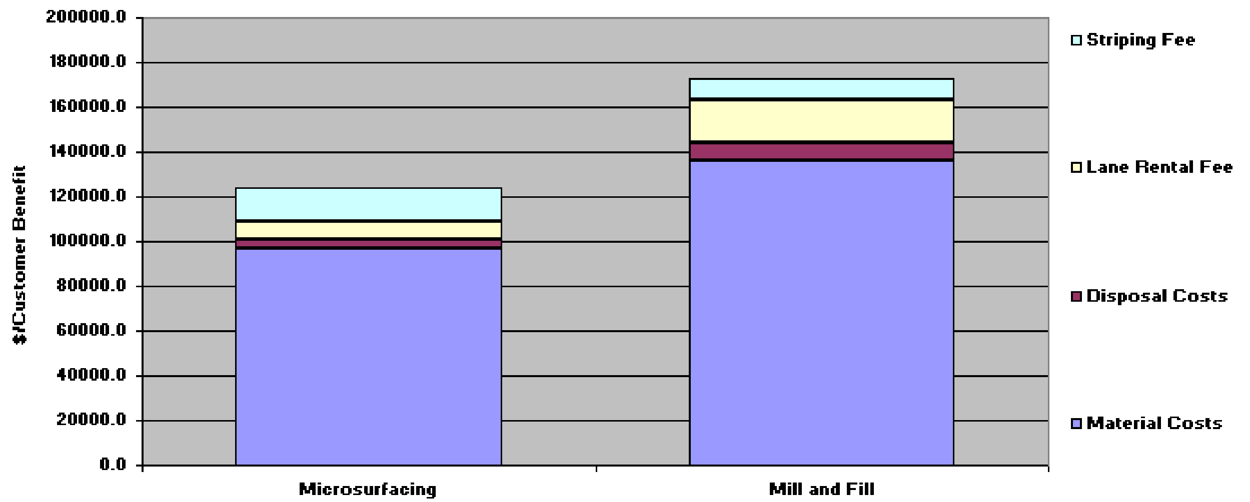



1,0 = worst position, better results ordered relatively, <1

Micro surfacing clearly demonstrates lower environmental burden in all impact categories relative to the Mill and Fill (hot mix overlay) alternative.

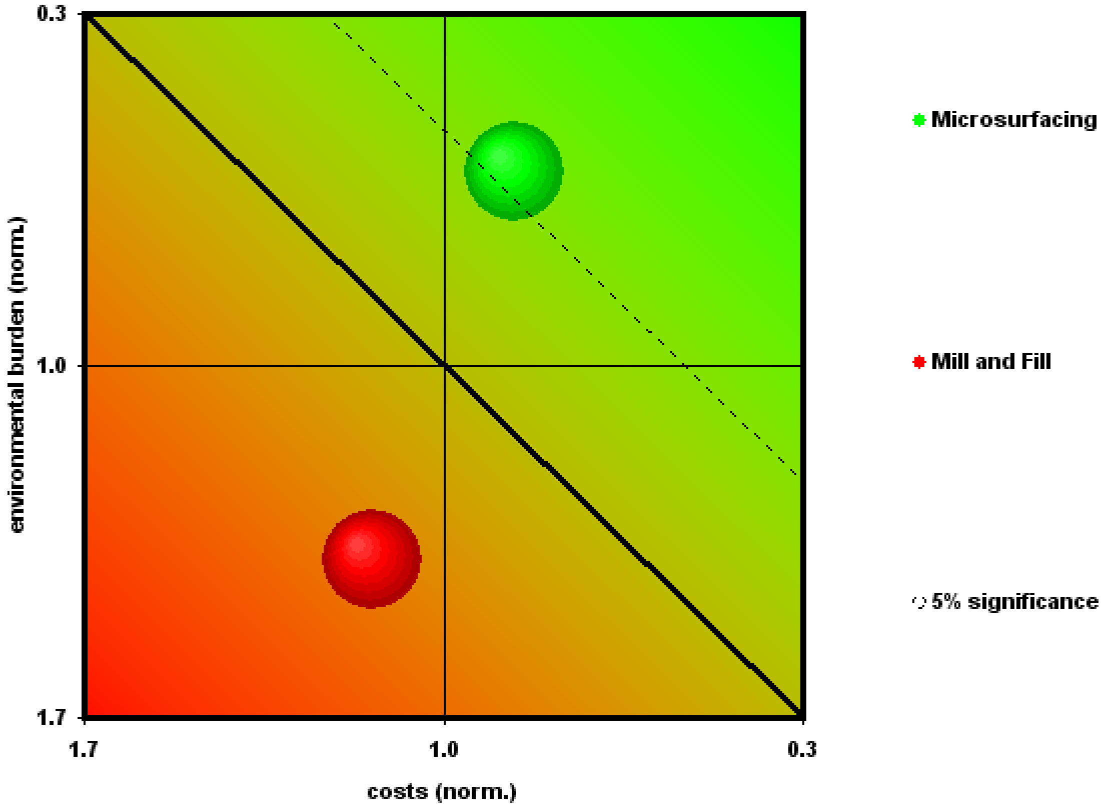
# Overall Economic Results

| Life Cycle Costs | | | |
|---|---|---|---|
| | | **Micro surfacing** | **Mill and Fill** |
| Material Cost | $/yd2 | $4.00 | $9.25 |
| Material and Labor Costs | $/CB | $97,079 | $136,037 |
| Disposal Costs | $/CB | $3,650 | $7,900 |
| Lane Rental Fees | $/CB | $7,740 | $19,505 |
| Striping Fee | $/CB | $15,633 | $9,651 |
| **Total Cost** | $/CB | $124,103 | $173,093 |



# Eco-efficiency Portfolio: Base case

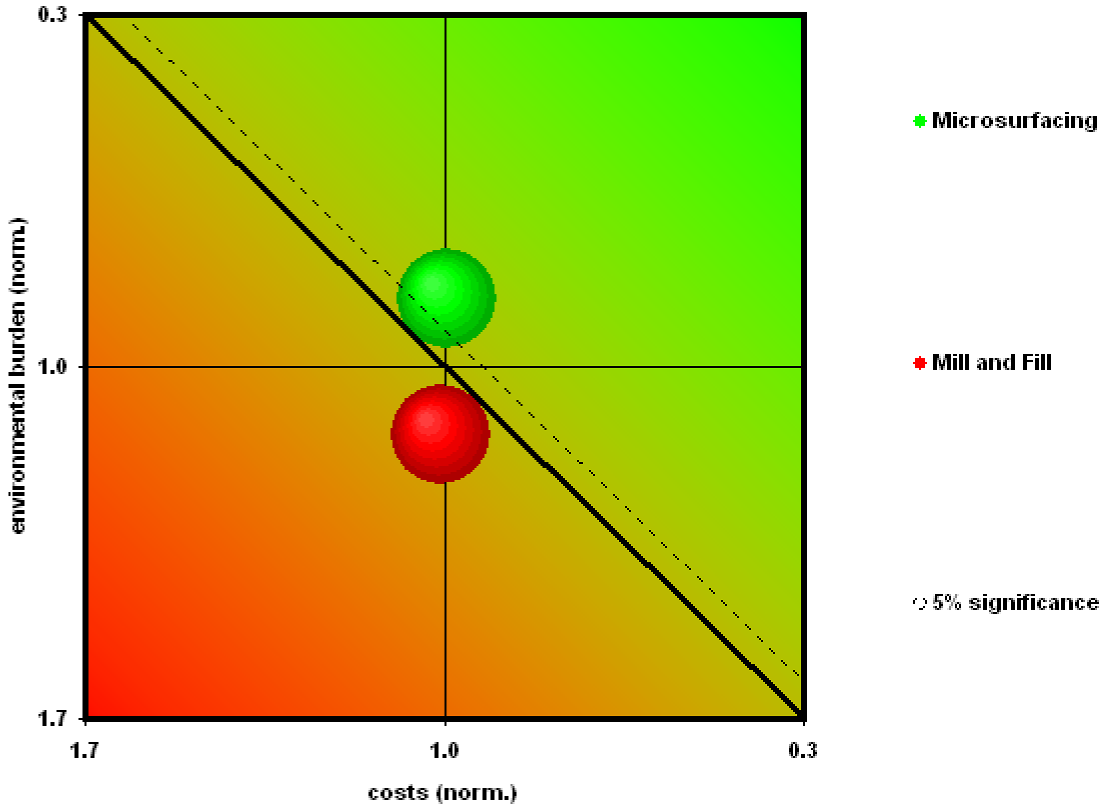
Preventive maintenance of a 1 mile stretch of a 12 foot lane of an urban road to a similar profile and performance using best engineering practices over a 40 year period




For this study, the micro surfacing alternative is the most eco-efficient.

# Eco-efficiency Portfolio: Scenario 1:
## 17 year durability for Mill and Fill

Preventive maintenance of a 1 mile stretch of a 12 foot lane of an urban road to a similar profile and performance using best engineering practices over a 40 year period




Scenario reflects increase from 11 to 17 years in durability for Mill and Fill and results in a significant improvement in relative eco-efficiency of Mill & Fill. Micro surfacing alternative still remains the most eco-efficient.

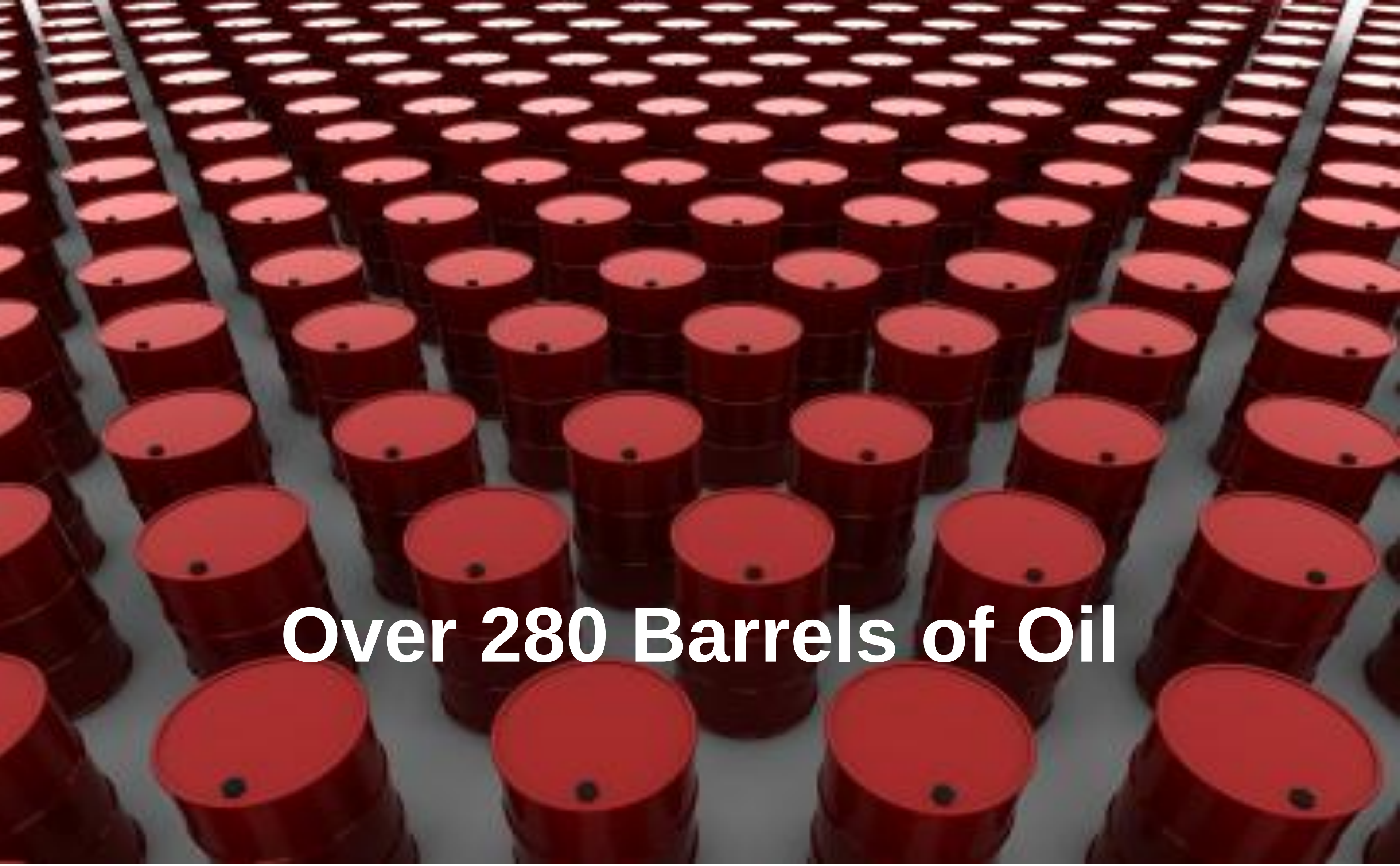
# Conclusions: For this analysis micro surfacing is the more eco-efficient pavement preservation technology !

.....clear environmental advantages in all 6 impact areas.

.....combined with the lowest life cycle cost.

Based on the 1 mile stretch of a 12 ft urban lane, micro surfacing relative to Thin Hot Mix Overlay (Mill and Fill) will save ..........

Savings equivalent to the total energy consumed by 110 residential US homes in a year


Over 280 Barrels of Oil

# Savings equivalent to removing over 3 cars from our roads

# Savings equivalent to the annual $CO_2$ sequestration of over 145 acres of mature forest

# 34 tons less municipal waste sent to landfills

# The Eco-efficiency of Chip Seals

A collaborative project by BASF and Colas

# Customer Benefit and Alternatives

## Customer Benefit

Preventive maintenance of a 1 mile stretch of a 12 foot lane of a rural road to a similar profile and performance using best engineering practices over a 40 year period.

## Hot Alternatives

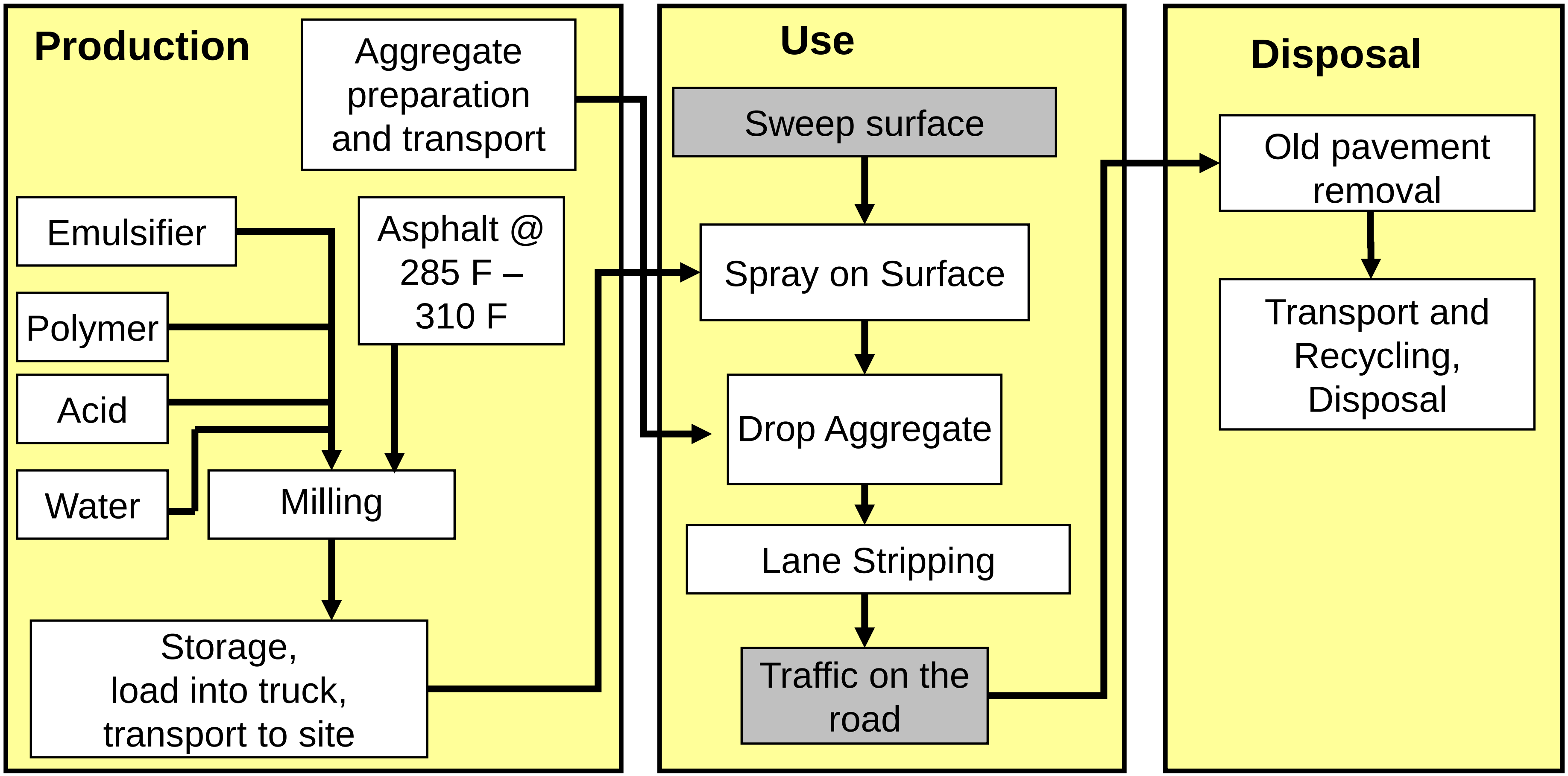
Hot Chip Seal, polymer modified non-emulsified with Ground Tire Rubber (GTR), AC-20-5TR

## Cold Products

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

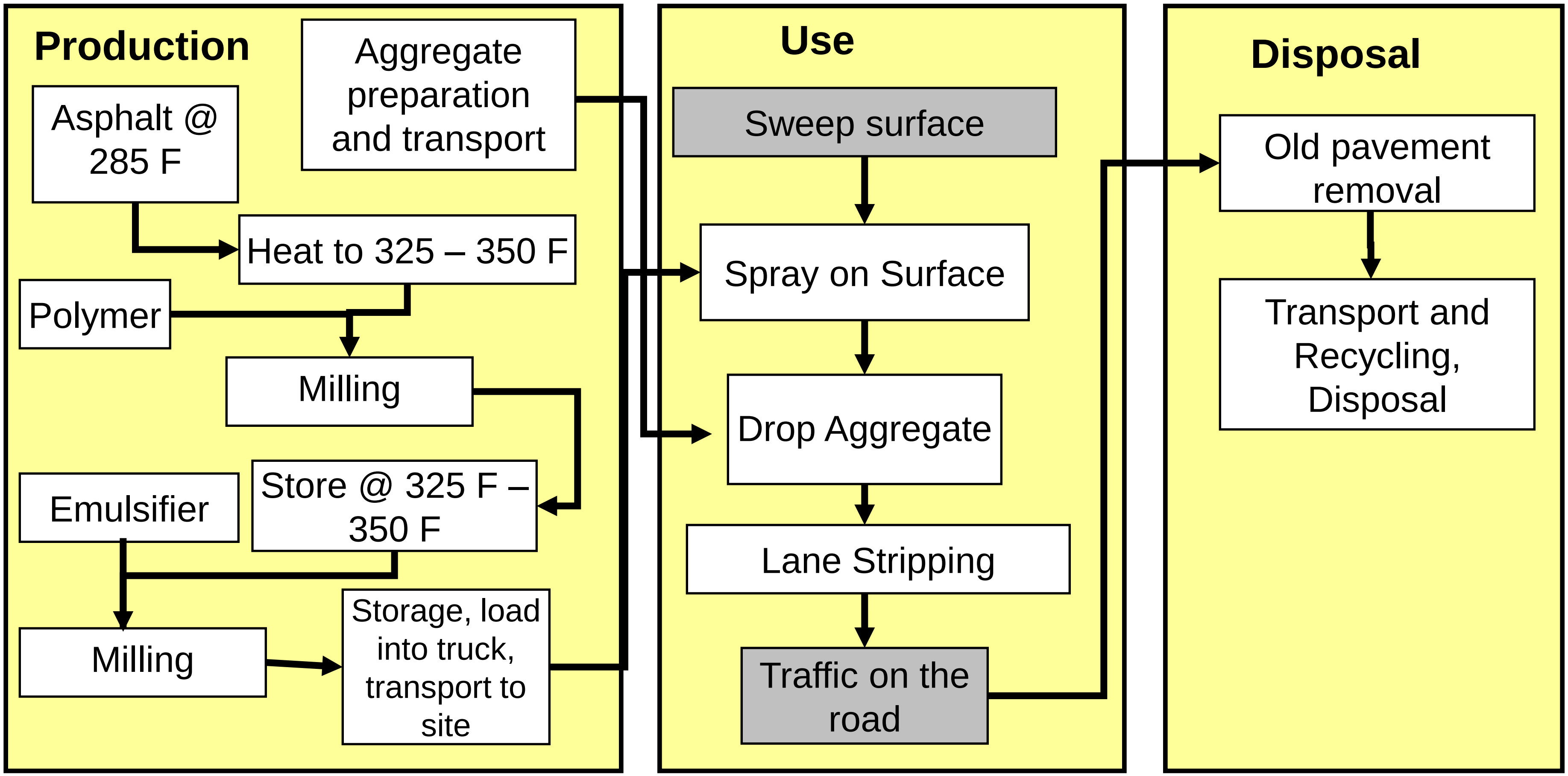
Polymer modified Chip Seal, emulsified asphalt (CRS-2P) using SBR polymers with fiber reinforcement

# System Boundaries - Polymer modified asphalt emulsion w/ SBR




*Grey boxes are not considered, since they are the same for all alternatives.*

# System Boundaries - Polymer modified asphalt emulsion w/ SBS

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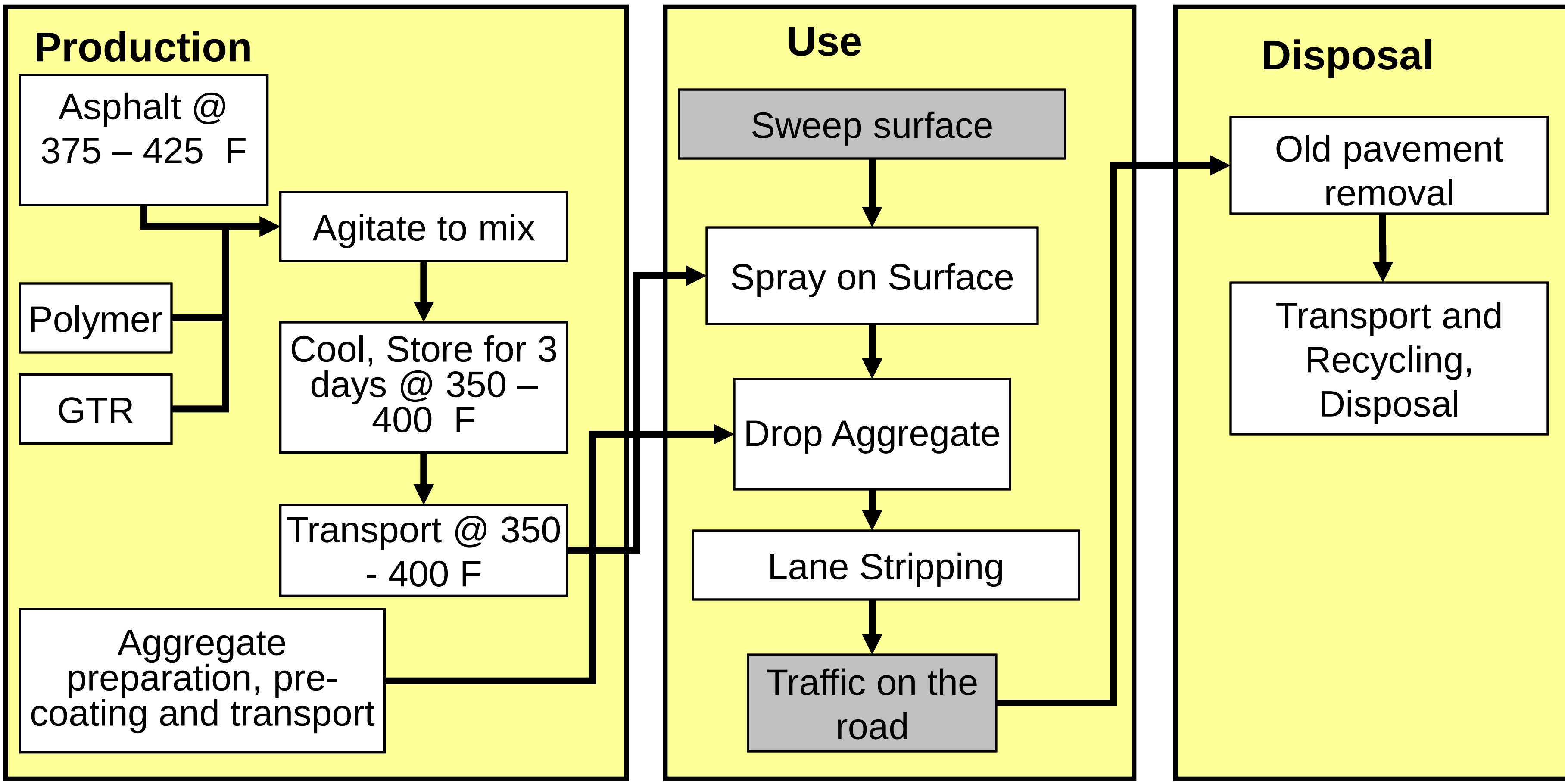
# System Boundaries – Hot polymer- modified GTR Chip Seal




*Grey boxes are not considered, since they are the same for all alternatives.*

# Key Project Assumptions

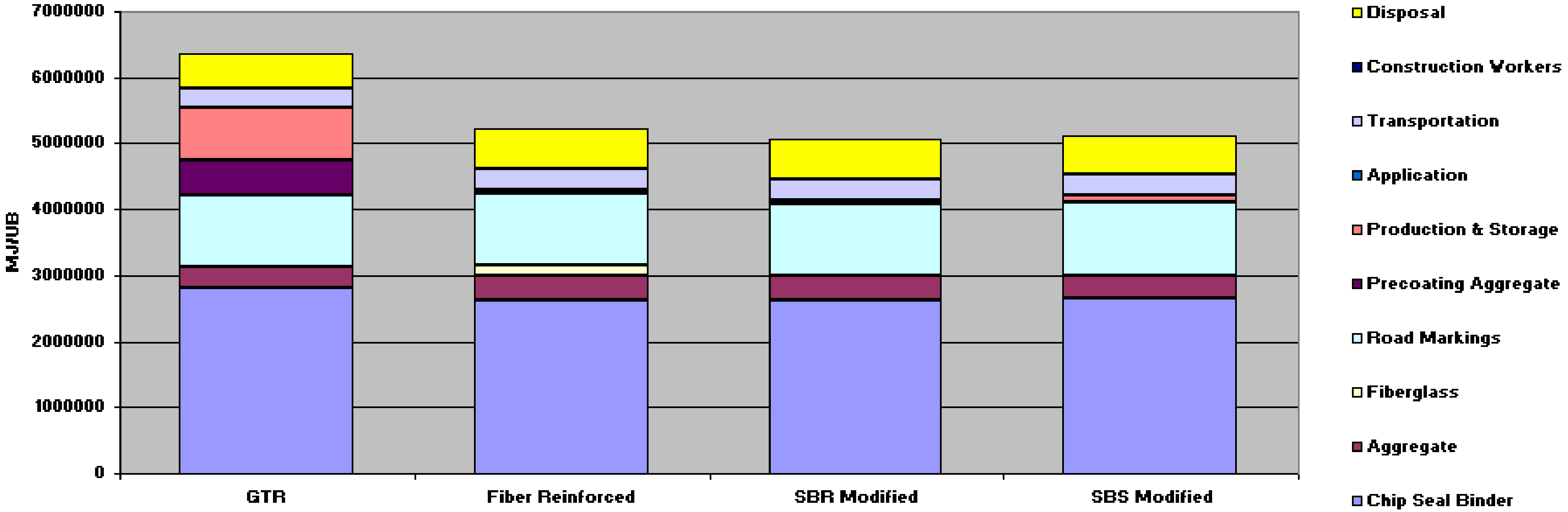
- Life expectancy data for the alternatives was obtained from a 3rd party (National Center Pavement Preservation) survey of state transportation agencies (17 states responding)
  - 6 years for all alternatives
- Life Cycle costing:
  - Both financial and social discount rates were used
  - Lane rental fees were used to capture the delay costs associated with construction activities
  - Costs for alternatives are industry/national averages and provided by manufacturers.
- Industry avg. data used for compositional data for alternatives.
- Credit (both environmental and cost) given to alternatives for remaining value left in road at end of study timeframe
- Data related to work zone accidents & fatalities obtained from DOT – FHWA data

# Key Project Assumptions

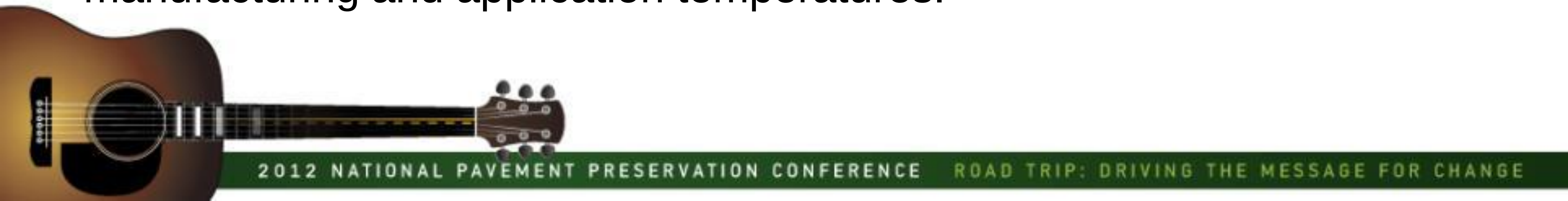
- Energy requirements for producing and applying the asphalt alternatives were obtained from:
  - IVL Swedish Environmental Research Institute's Life Cycle Assessment of Road, 2nd edition 2001.
  - Colas, Life Cycle Analysis, The Environmental Road of the Future, 2003
  - Various manufacturer – industry data
- Energy for grinding tire rubber was considered
- Transportation Impacts consideration:
  - Binder – Fiberglass:  100 km
  - Aggregate:  50 km
  - Disposal – Recycle:  100 km

# Environmental Impact

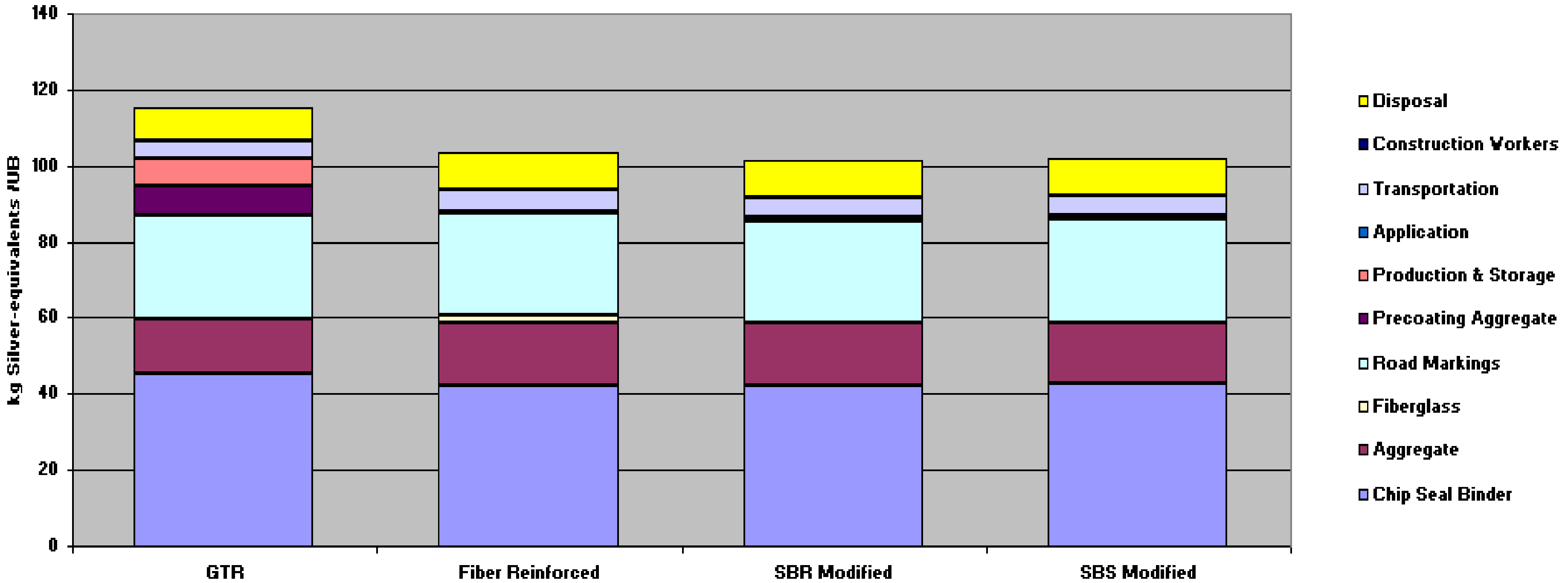
## Energy Consumption




The biggest contributor to energy consumption for each alternative is the manufacture of the asphalt binder.  GTR has the highest impact based on the extra requirements for pre-coating the aggregate as well as higher manufacturing and application temperatures.

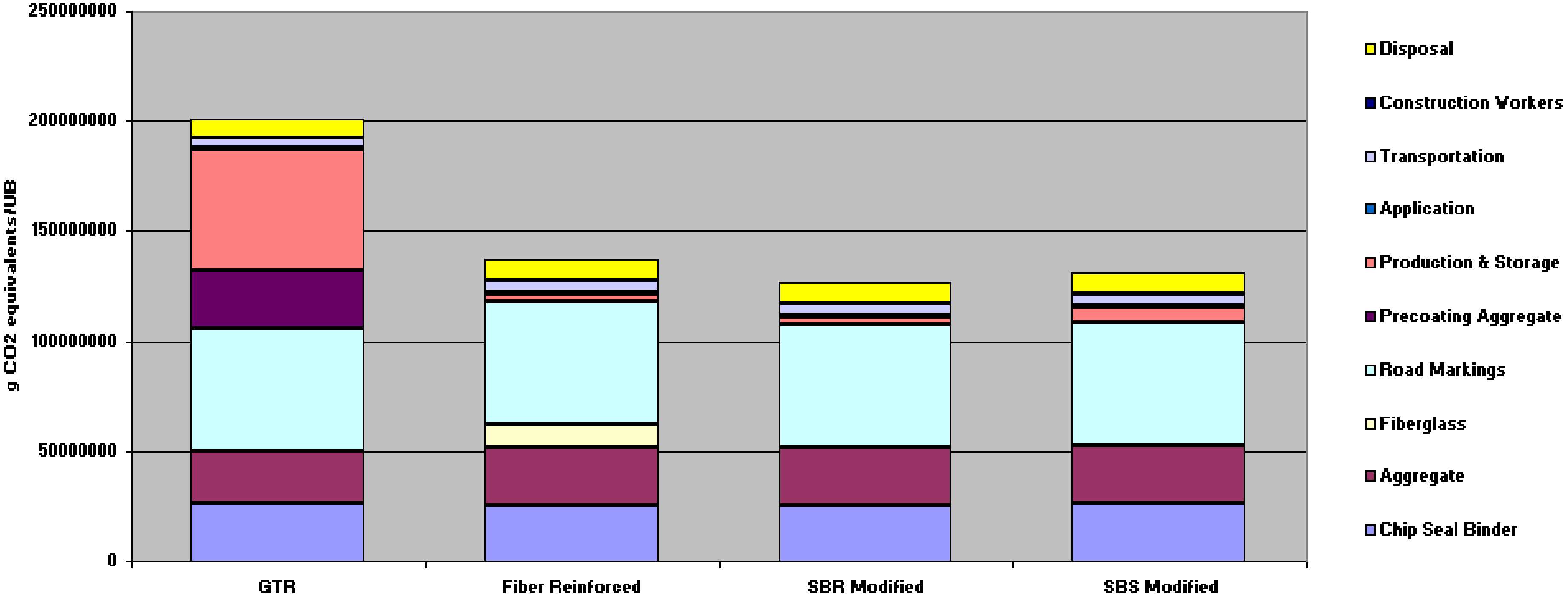


# Environmental Impact
## Resource Consumption




The asphalt binder, aggregate, road markings and disposal/transportation modules have the largest impact in the raw material usage category.

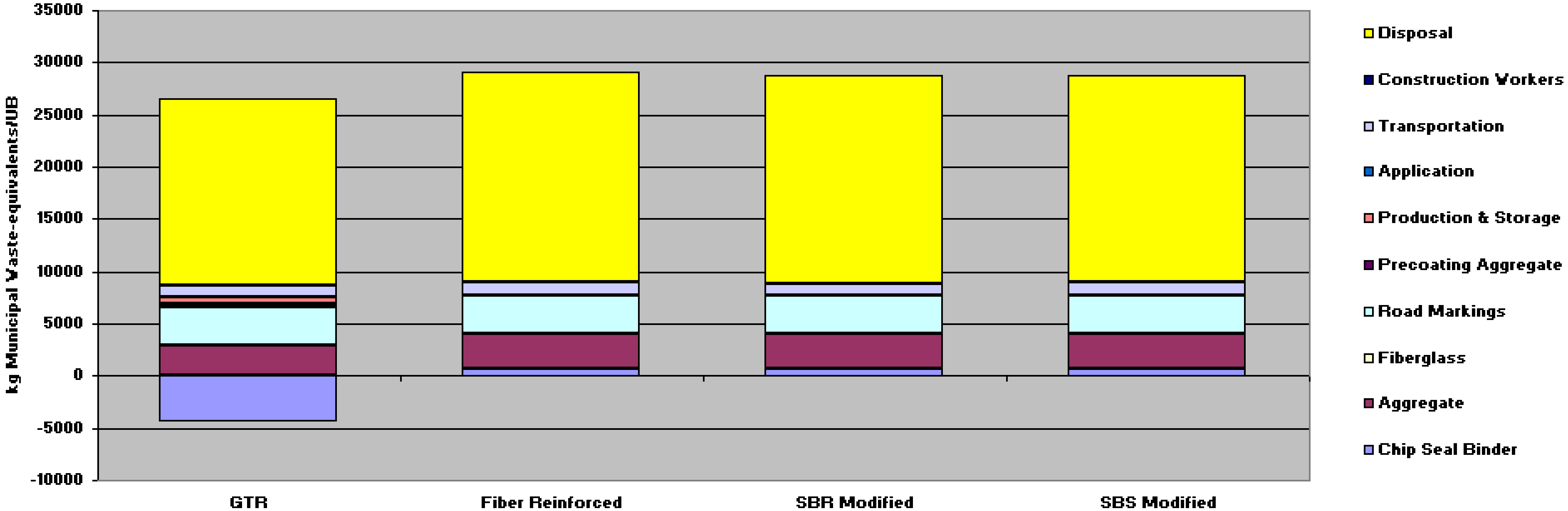
# Environmental Impact
## Global Warming Potential




Activities related to the production and storage of GTR as well as the pre-coating of aggregate contribute to GTR having the highest GWP. $CO_2$ emissions from the manufacturing / application of the road markings also is a significant contributor.

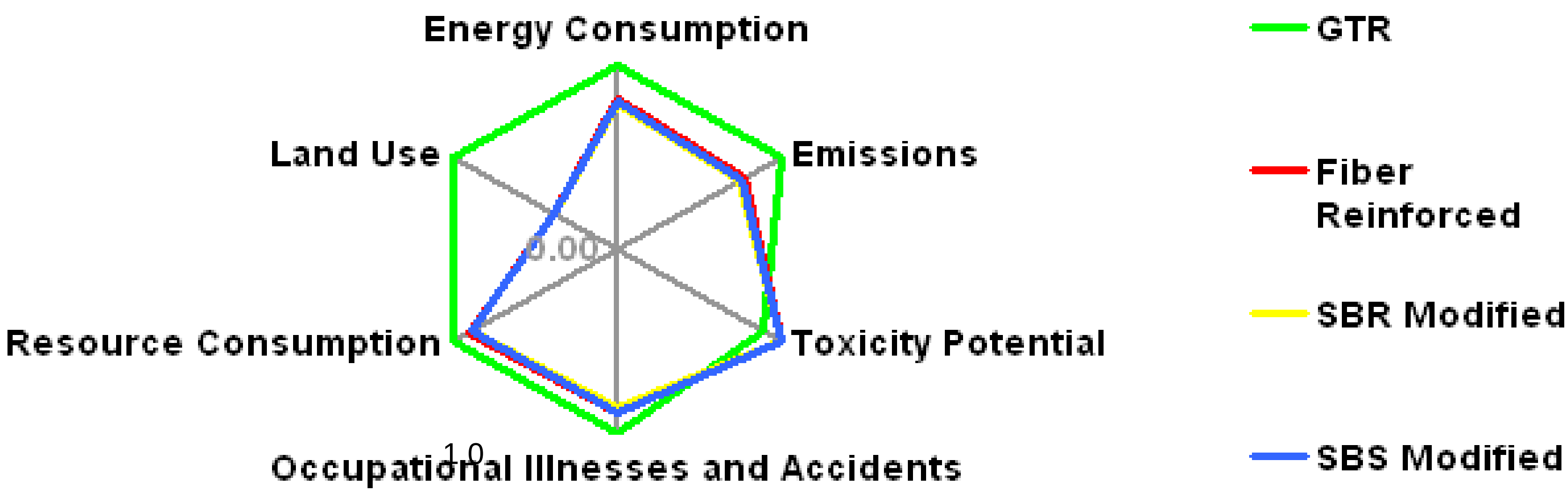
# Environmental Impact

## Solid Waste Emissions




GTR has the lowest impact for solid waste emissions. This is directly related to the diversion of tires from landfill and use in the GTR chip seal.

# Environmental Fingerprint




**1,0 = worst position, better results ordered relatively, <1**

GTR chip seal scores highest in all categories except toxicity potential. Emulsion based technologies score similar impacts.

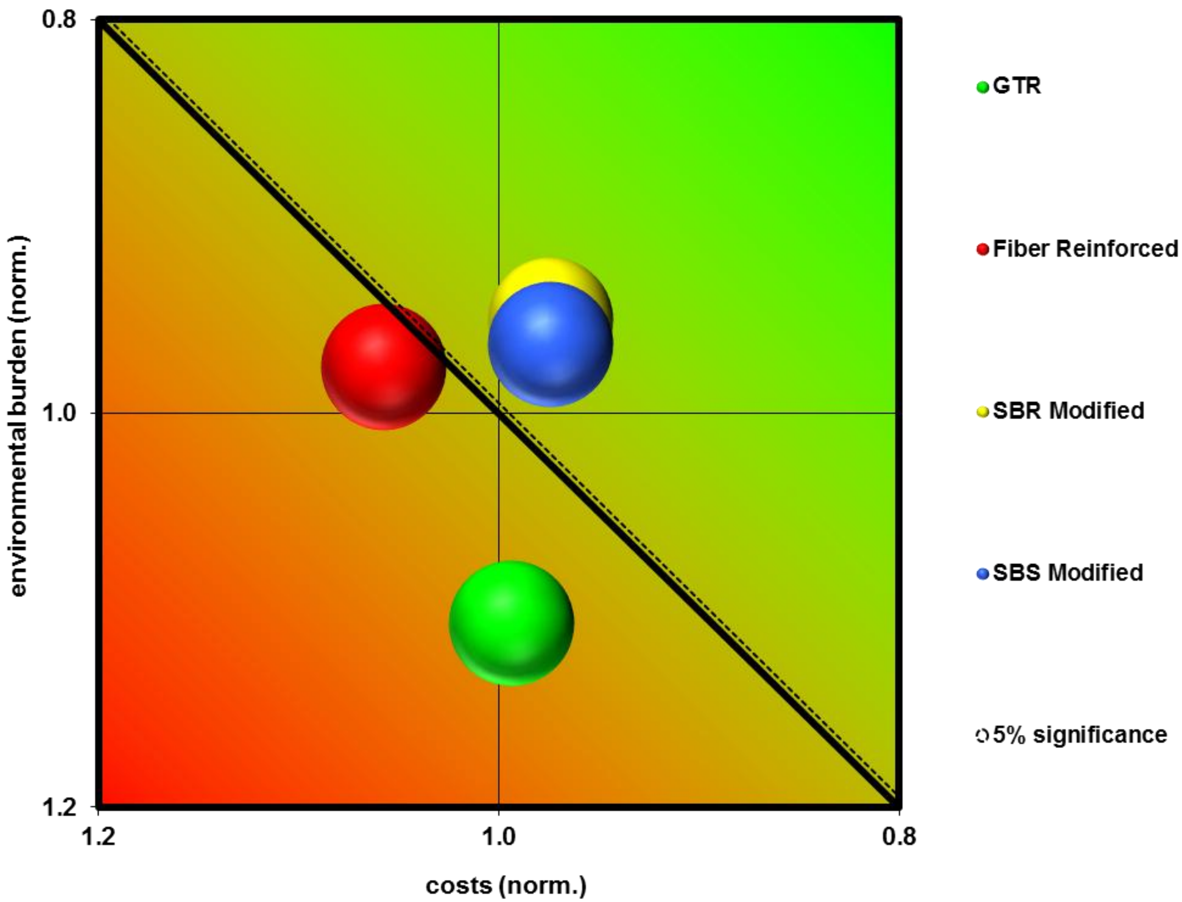
# Overall Economic Results

| LIFE CYCLE COSTS | | GTR | Fiber Reinforced | SBR Modified | SBS Modified |
|---|---|---|---|---|---|
| Chip Seal material Cost | $/yd2 | 2.37 | 2.8275 | 2.262 | 2.262 |
| Pavement Costs | $/CB | $57,519 | $64,642 | $54,898 | $54,898 |
| Striping Material Cost | $/CB | $15,633 | $15,633 | $15,633 | $15,633 |
| Disposal Costs | $/CB | $2,965 | $3,321 | $3,306 | $3,306 |
| Lane Rental Fees | $/CB | $15,481 | $15,481 | $15,481 | $15,481 |
| Total Cost | $/CB | $91,598 | $99,076 | $89,318 | $89,318 |

The installed material costs is the largest contributor to the overall life-cycle costs. The SBR/SBS emulsion technologies have the lowest overall life-cycle cost for this study. Fiber Reinforced has the highest life-cycle costs.

# Eco-efficiency Portfolio: Base case

Preventive maintenance of a 1 mile stretch of a 12 foot lane of a rural road to a similar profile and performance using best engineering practices over a 40 year period

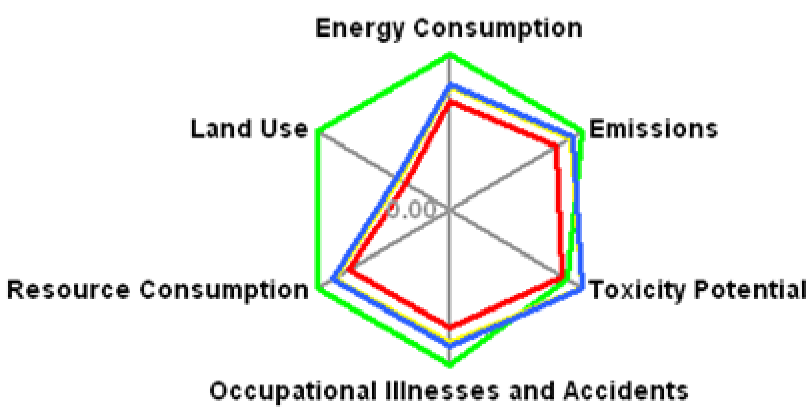


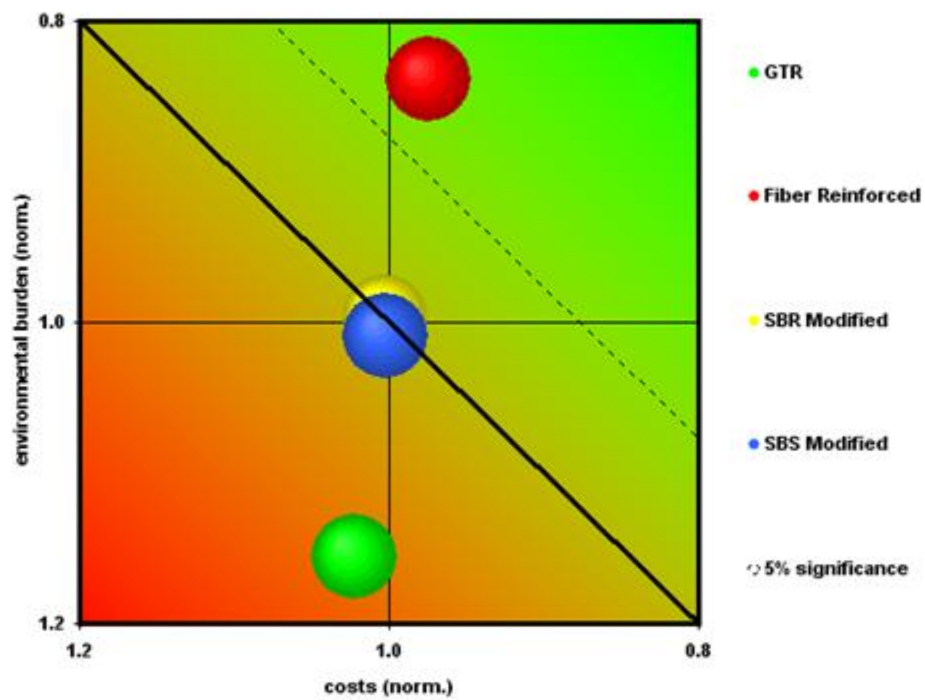

For this study, the SBR/SBS emulsion chip seals are the most eco-efficient.

# Eco-efficiency Portfolio:

## Scenario #1: Increased durability for Fiber Reinforced

| LIFE CYCLE COSTS | | GTR | Fiber Reinforced | SBR Modified | SBS Modified |
|---|---|---|---|---|---|
| Chip Seal material Cost | $/yd2 | 2.37 | 2.8275 | 2.262 | 2.262 |
| Pavement Costs | $/CB | $57,519 | $56,135 | $54,898 | $54,898 |
| Striping Material Cost | $/CB | $15,633 | $13,701 | $15,633 | $15,633 |
| Disposal Costs | $/CB | $2,965 | $2,747 | $3,306 | $3,306 |
| Lane Rental Fees | $/CB | $15,481 | $13,636 | $15,481 | $15,481 |
| | | | | | |
| Total Cost | $/CB | $91,598 | $86,220 | $89,318 | $89,318 |



EFFICIENCY IN ECOLOGY AND ECONOMY

# For More Information:

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