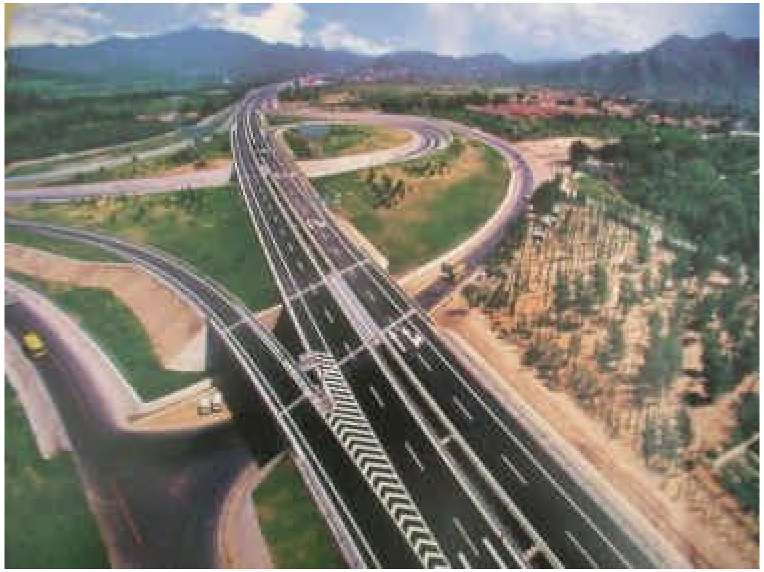
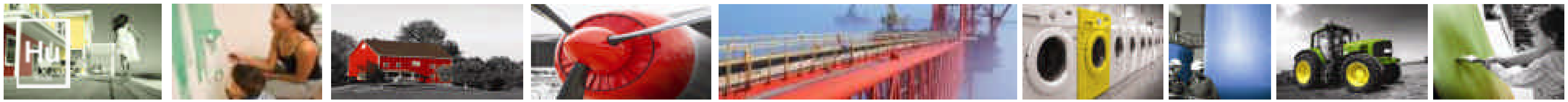
Coating Materials

Life Cycle Assessment (LCA) as a tool to evaluate the environmental impact of water-based, solvent-based and Hot Melt Road Marking Materials





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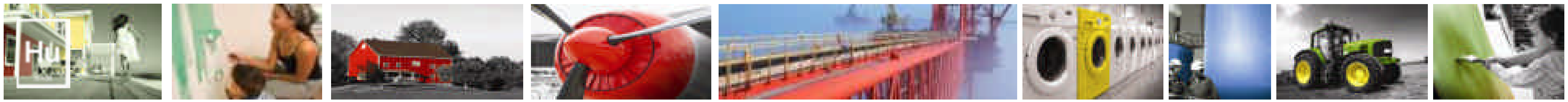
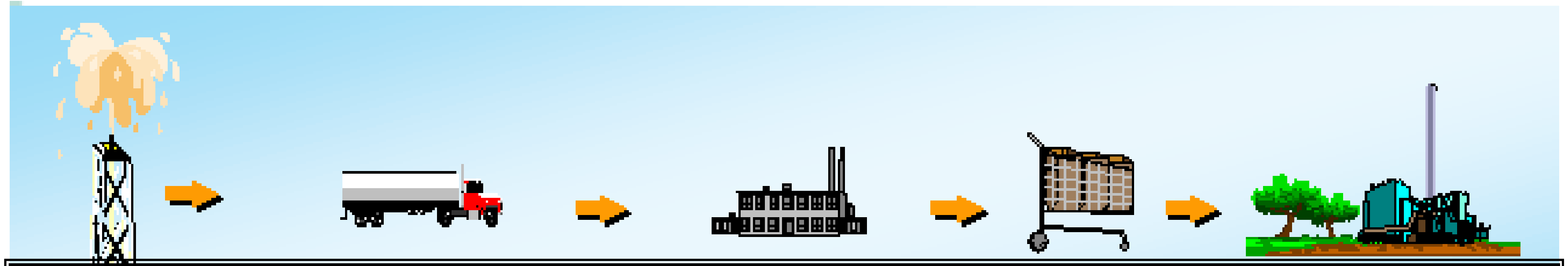


LCA Principles



Extraction of raw materials - Transport - Fabrication & Packaging - Distribution Consumption - Waste handling

LCA is a method used to quantify the effects of a product or a service from the extraction of raw materials to disposal

Performed in accordance to International (ISO 14040 to 14043) standards

Preamble

- Paper based on an amalgam of 2 separate reports
    - » Solvent vs Water
    - » Water vs Hot Melt

- Data based on absolute statistics

  Consistent measurement to international standards

  Audited by Independent Accounting Firms

  Peer Reviewed

  Data presented based on stated assumptions

- No commentary on the suitability of products for specific purposes

Objective of the LCA Study

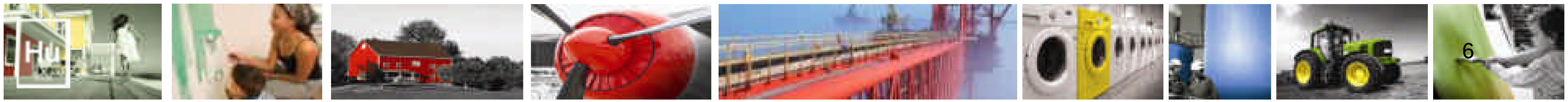
Evaluate the environmental and human health impact of water based and solvent based acrylic, and hot-melt road markings over the proposed life cycle

Impact on 19 factors across 6 categories

- Air Pollution
- Water Pollution
- Ground Pollution
- Toxicity to Humans
- Toxicity to the Environment
- Use of Earth Resources

Environmental impact categories and indicators assessed

Areas	Indicators	Units
Resources	Primary energy	MegaJoule
	Depletion of non-renewable resources	Year-1
Air Pollution	Acidification of air	g eq. H+
	Greenhouse effect (CO2 release)	g eq. CO2
	Metal in air	g
	VOC in air	g
Water Pollution	Eutrophication	g eq. PO4
	Metals in water	g
	Organic matter in water	g
	Suspended solid oxidizable matter	g
Soil Pollution	Metals in soil	g
	Paint waste emitted to soil	g
Waste	Hazardous industrial waste (Class I)	kg
	Municipal and industrial waste (Class II)	kg
	Inert waste (Class III)	kg
Toxic risks	Aquatic ecotoxicity	g eq. 1,4-DCB
	Human toxicity	g eq. 1,4-DCB
	Sediment ecotoxicity	g eq. 1,4-DCB
	Terrestrial ecotoxicity	g eq. 1,4-DCB

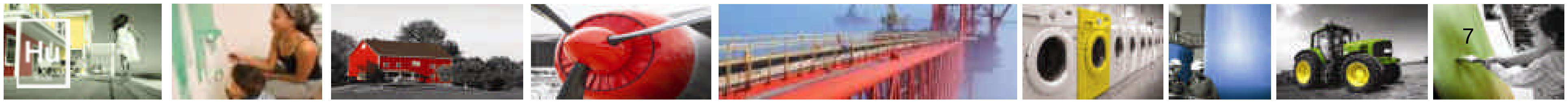


Functional Unit

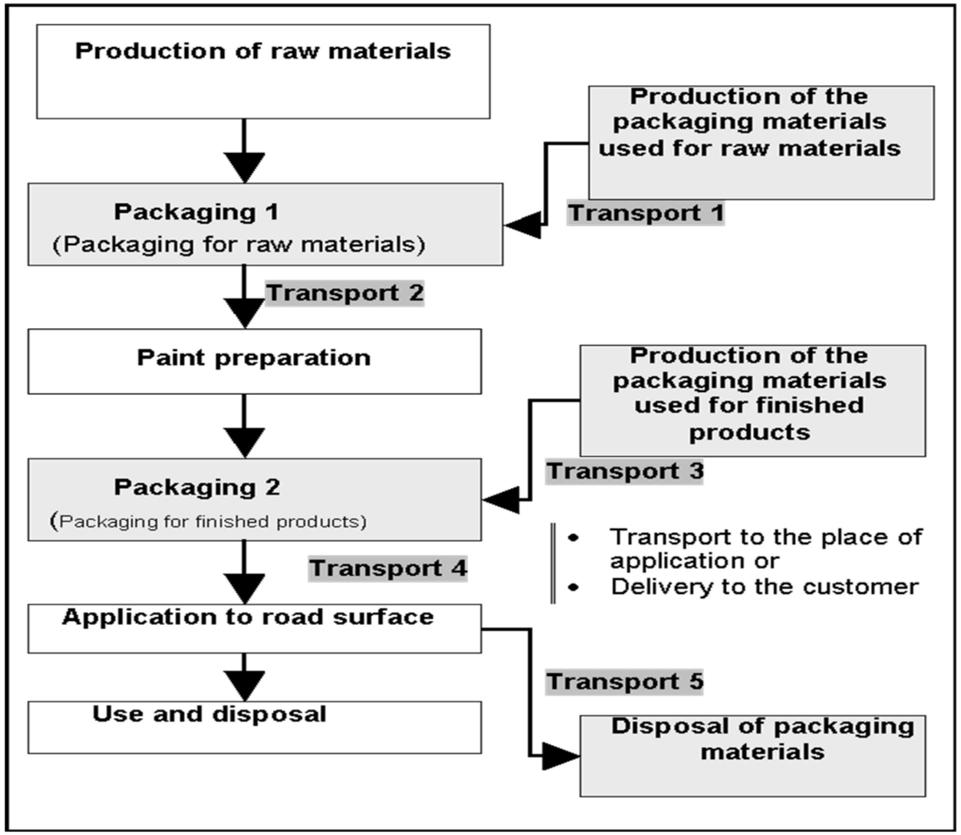
To cover **1 m²** of **highway** with **white colour reflective traffic markings** for **10 years** (performing to defined standards*)

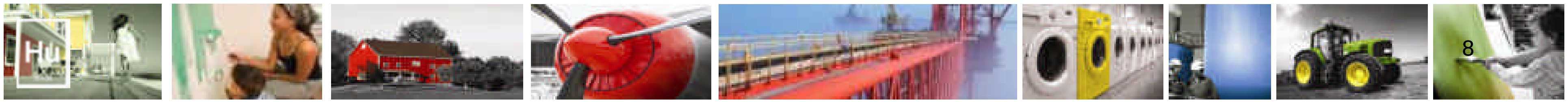
Life cycle calculations are based on a function or service rendered by a product

- **For the purpose of the consistency, it is assumed that all materials have an in-service life of 1 year.**
    - *retroreflectivity, skid resistance, wear, luminance

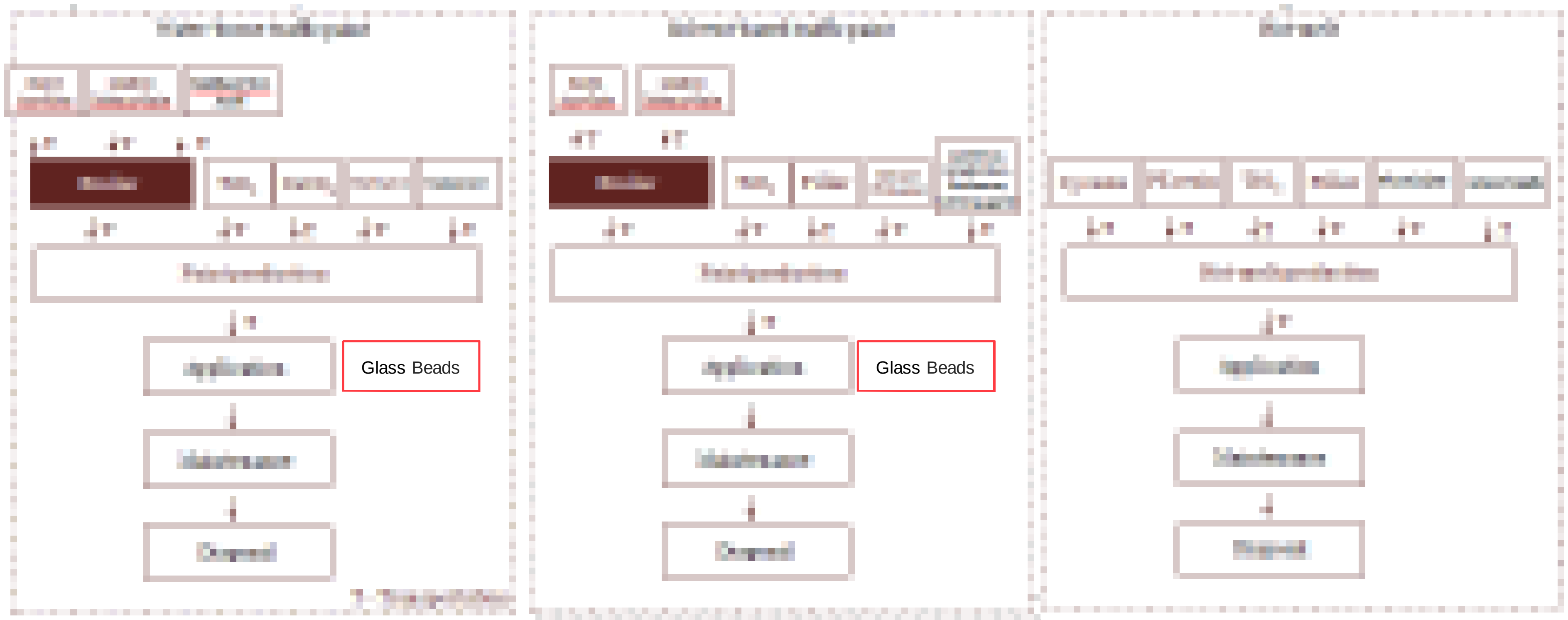


Process Flow





Process Flow



Rohm and Haas Formulation TP-27-1

(Based on Rohm and Haas Paraloid B66 traffic paint formulation).

(Generic formulation sourced from various inputs)

Base Compositions

Commercial water-based acrylic paint

Base components: all acrylic emulsion polymer, titanium dioxide, filler, water, coalescent, ammonium, thixotrophic agent and wetting agent. The paint contains 42% water and less than 4% solvent. 400 gm/ m2 glass beads on application). (Rohm and Haas formulation TP-27-1)

Commercial solvent-based acrylic paint

Base components: solvent based acrylic polymer, titanium dioxide, filler, toluene, plasticizer, thixotrophic agent and wetting agent. Contains approximately 30% toluene. 400 gm/ m2 glass beads on application. (Based on Rohm and Haas Paraloid B66 traffic paint formulation).

Commercial Hot –melt Roadmarking

Base components: C5 Resin, PE resin, plasticizer, TiO2 and fillers. (Various inputs).

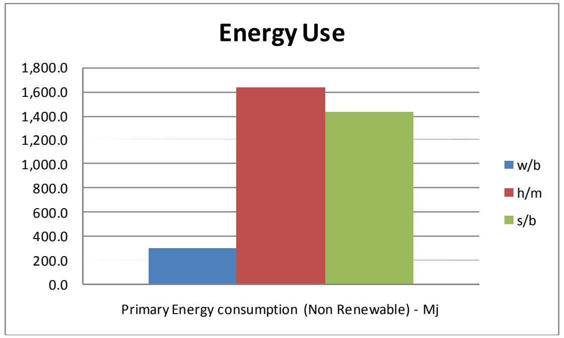
Component	Waterbased	Solventbased	Hot Melt
Binders	267	139	195
Titanium Dioxide	56	125	50
Fillers	415	254	530
Solvents	24	251	
Glass Beads *	216	216	200
Other	22	15	25
	1000	1000	1000

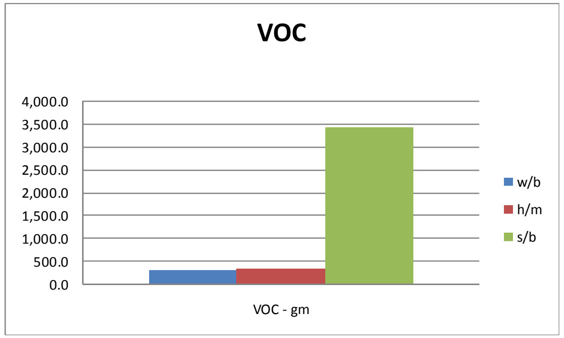
* Glass Beads added on application

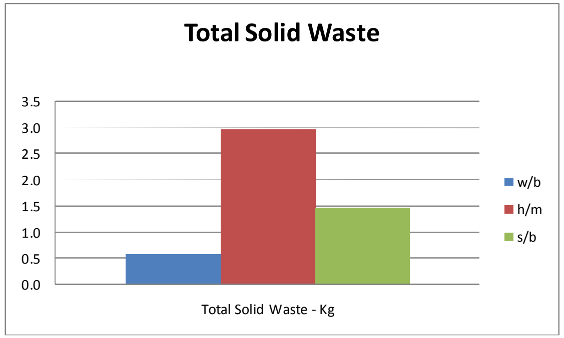
Source of data

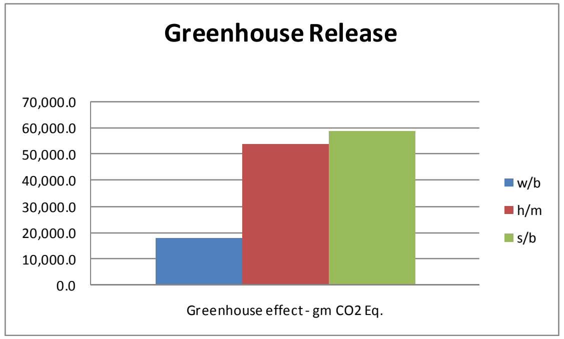
- The data of this LCA study is obtained from multiple sources, include:
  - Direct data collected from Dows Manufacturing and Technical Facilities(limited to binders for water-borne and solvent-based traffic paint);
  - Literature research of academic papers and national/sectoral standards;
  - Interviews with research institutes and regulatory authorities;
  - Interviews with major paint/hot-melt producers and applicators in Europe, Asia and North America.

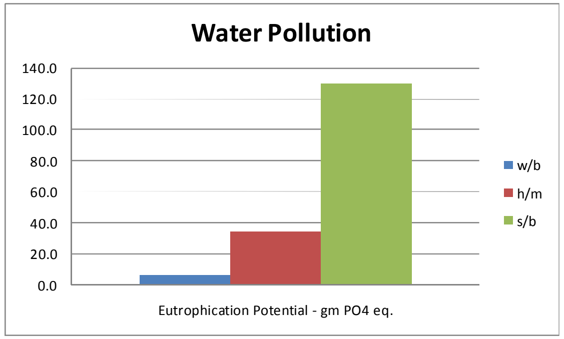
Impact Sources

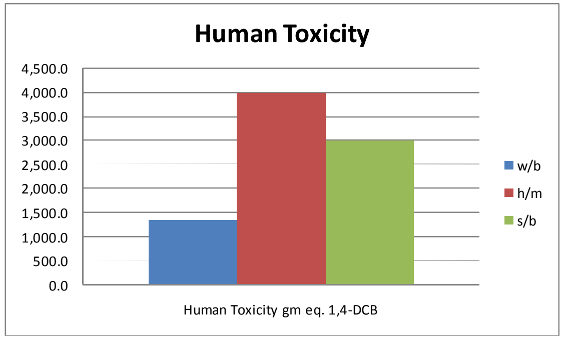


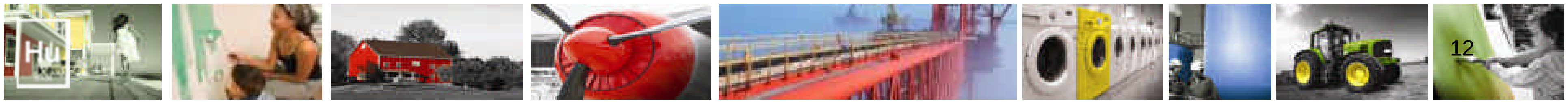












Summary of impacts

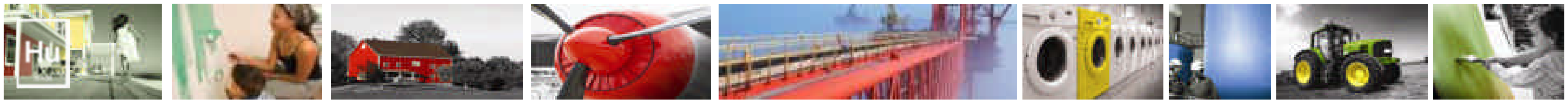
- Water Based
  - Binders contribute the most significant impacts except water and VOC
  - TiO2 contributes most water consumption and impact on many other categories, reflecting it's environmental impact
  - The production process contributes relatively small impact compared to RM inputs

- Solvent Based
  - Binders and VOC as per water based
  - Solvents contributes most VOC , energy input and environmental and Human toxicity
  - The production process contributes relatively small impact compared to RM inputs

- Hot Melt
  - Similar to water based paint, production for repaint contributes the most impact for all impact categories.
  - The thickness of application is also a major factor relative to paint
  - Application stages also contributes the most significant proportion to greenhouse effect

LCA Balance Sheet

Impact Category	Unit	Water-based	Hot-Melt	Solvent-based
Primary Energy consumption (Non Renewable)	Mj	300	1,639	1,430
Total water Consumption	Litre	83	305	115
Chemical Oxygen in Demand (COD)	gm	5	23	26
VOC	gm	326	350	3,440
Total Solid Waste	Kg	1	3	1
Greenhouse effect	g CO2e	18,053	54,068	58,640
Depletion of Non Abiotic Resources	Kg Antimony Equiv	0	1	0
Acidification Potential	g SO2e	94	386	130
Eutrophication Potential	g Phosphate equiv	6	34	33
Human Toxicity	g Heamotolocical Tox equiv	1,344	3,972	3,000



Conclusions

- Water based road marking paints present the best LCA balance sheet based on the defined standards
- All impact factors studied are in favor of the water based technology
- With solvent based paints in particular the application phase is of concern with respect to human health and greenhouse release sourced from VOC's.

In conclusion, WB paints offer the best results in minimising the Environmental and Safety impacts of the three systems tested