



Environmental benefits of two-lift pavement

A quantitative perspective based on life cycle
assessment (LCA)

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In collaboration with the CP Tech Center



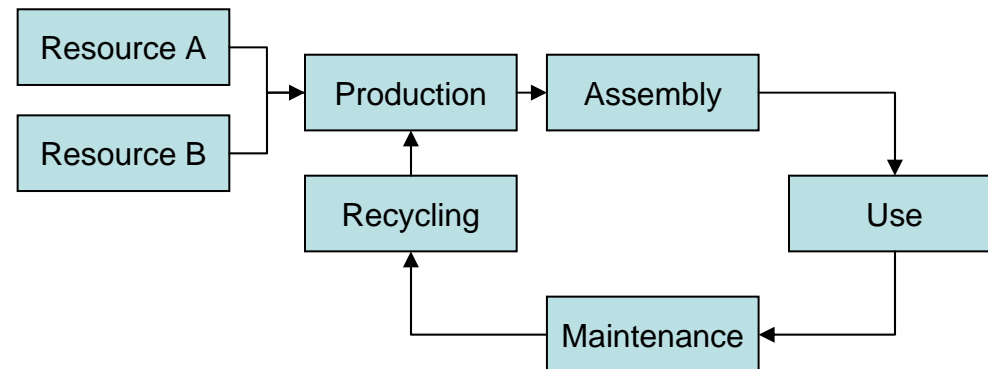
Topics

1. What is LCA?
2. Our experience
3. Two-lift case
4. What's next

Life cycle assessment (LCA)

LCA is a powerful tool for assessing the environmental performance of products, services or scenarios

It is based on material and energy flows for processes and materials that together form a life cycle





Life cycle assessment (LCA)

We use world-leading software and databases and apply ISO standards

- ISO 14041 Goal and Scope Definition
- ISO 14042 Inventory Analysis
- ISO 14043 Interpretation
- ISO 14044 Guidelines and principles
- ISO 14025 Type III environmental declarations

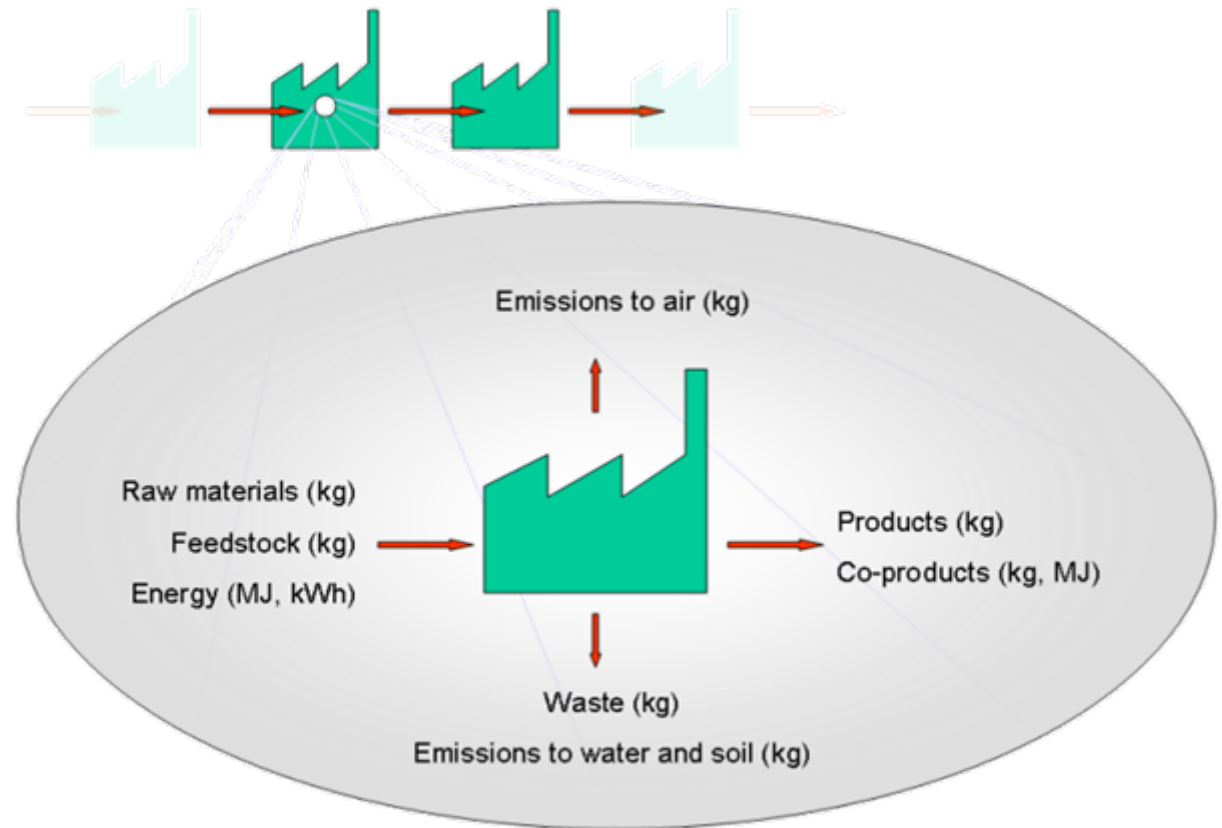


Goal and Scope

Functional unit: what is to be assessed in terms of:

- Amount
- Unit
- Functions
- Requirements
- Geographical considerations
- Timeframe

Inventory

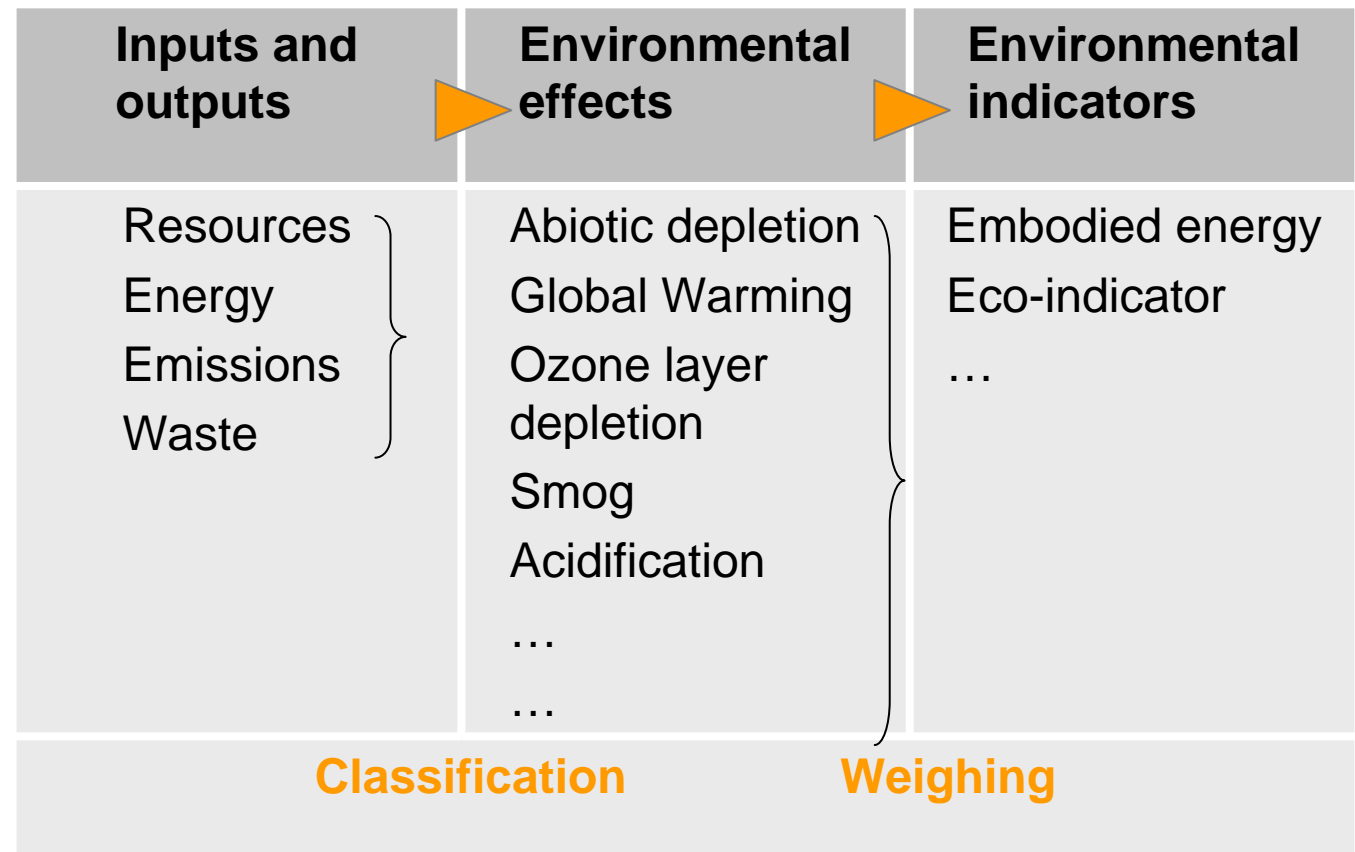


Impact Assessment

A range of impact categories

- global warming
- depletion of non-renewables
- depletion of the ozone layer
- acidification
- eutrophication
- summersmog
- aquatic ecotoxicity
- terrestrial ecotoxicity
- human toxicity
- energy
- non-hazardous waste
- hazardous waste
- ...

Impact Assessment



Impact Assessment

Inputs and outputs	Environmental effects	Environmental indicators
1 kWh of electricity	Global Warming	

Use of equivalency factors

From carbon dioxide and methane to global warming

1 kg carbon dioxide = 1 kg GWP-equivalents

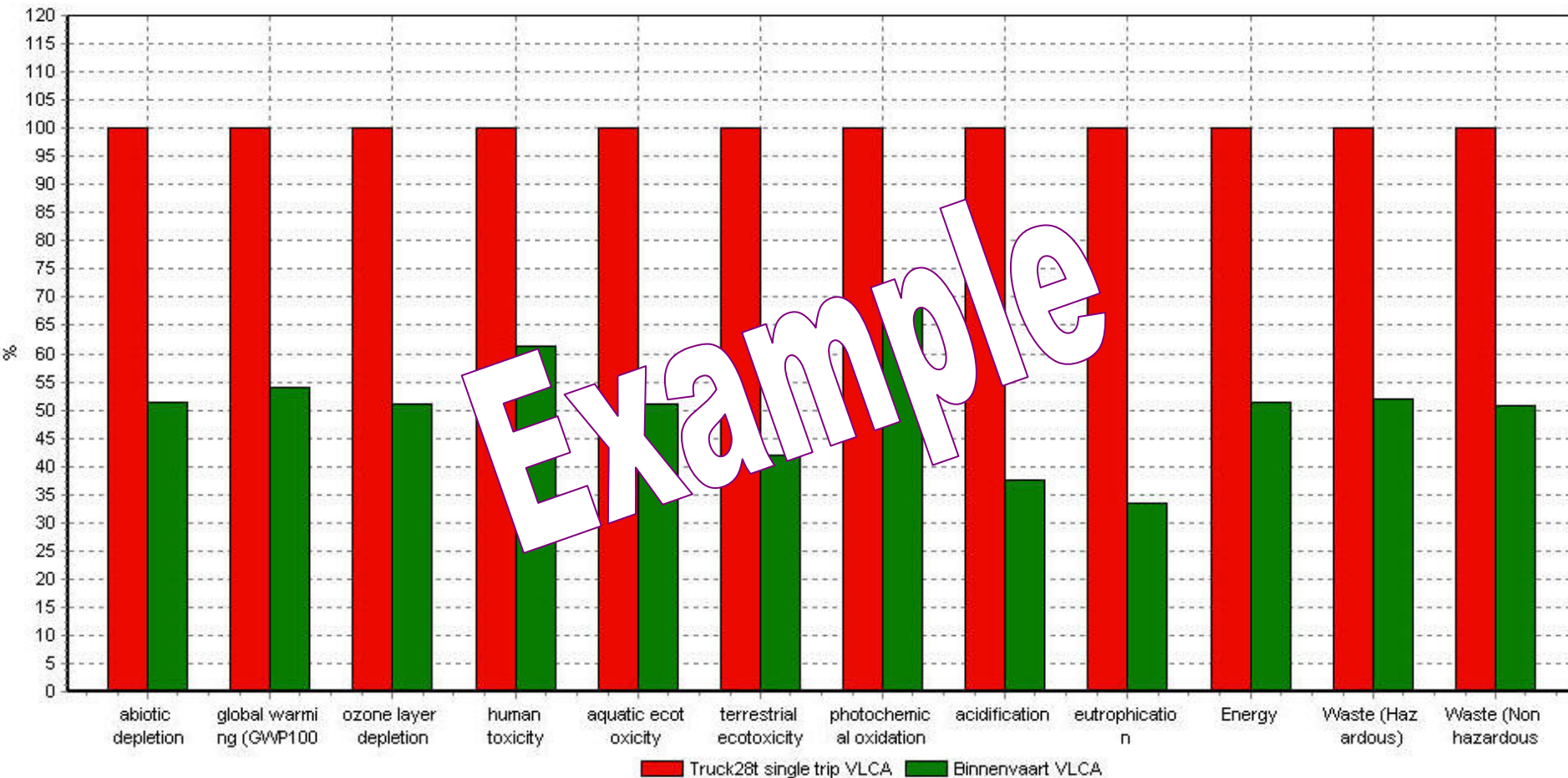
1 kg methane = 24 kg GWP-equivalents

Total = 25 kg GWP-equivalents

Source: IPCC

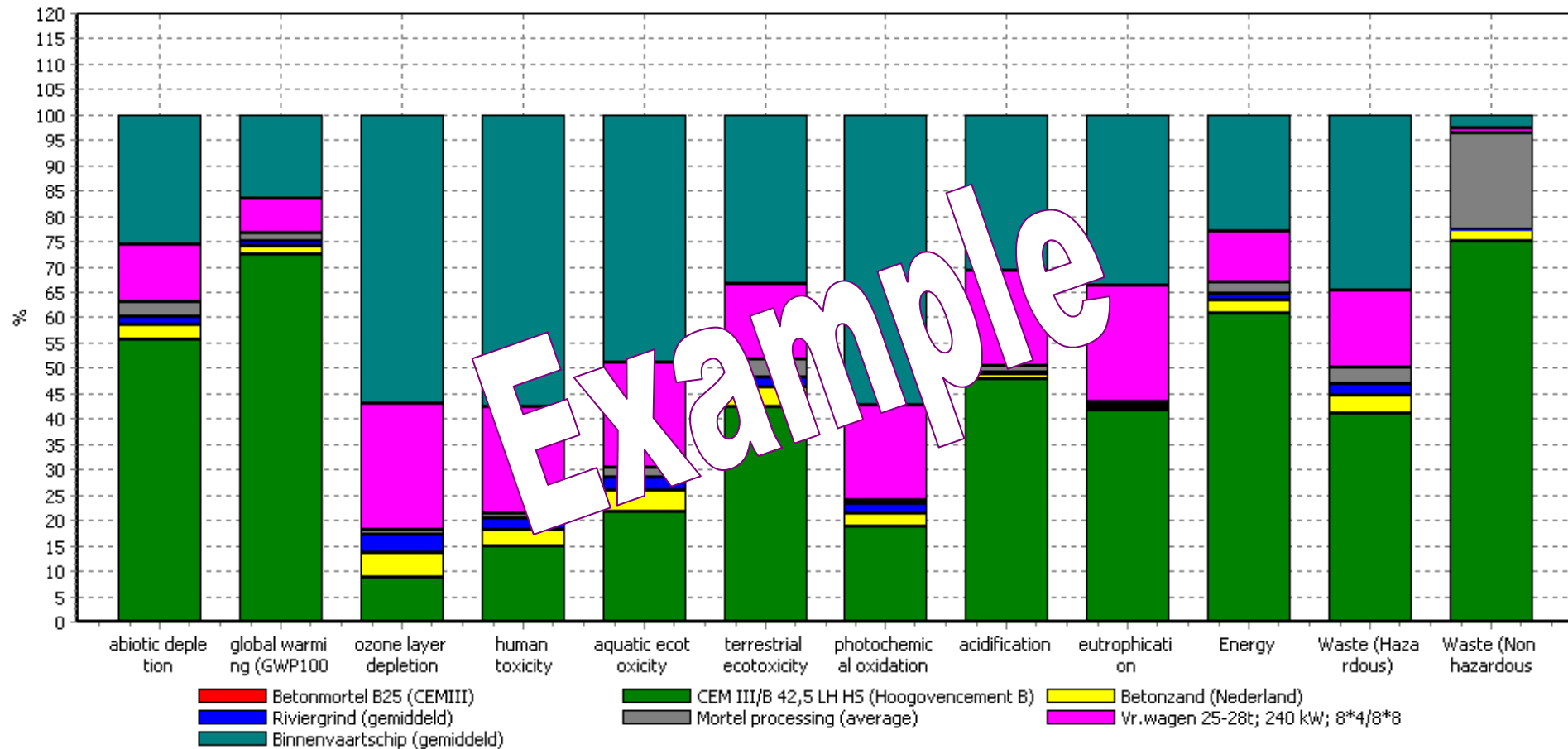
Impact Assessment

The result is an Environmental profile



Interpretation

Major contributions give options for improvements





Our experience

Over 10 years of consulting with CEMBUREAU, EFCA, BIBM, ERMCO, UEPG, HOLCIM, HEIDELBERG, ENCI, CBR, ITALCEMENTI, ready mixed, prefab drafting national standards for EPD, EU funded research project such as EcoServe, Carbon footprinting, Sustainability frameworks, databases, tools to educate the industry, language development. Consulting for European DOTs on green purchasing, environmental road design selection, tool development, standardization, feasibility of recycling scenarios, thermal concrete recycling, local secondary resources, comparisons, labeling, benchmarking,

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Two-lift Kansas

Comparison of:

1. Traditional
2. Two-lift
3. Optimized two-lift

Together with Tom Van Dam, APTEch
Gary Fick, Trinity Construction Management
Peter Taylor, CP Tech Center

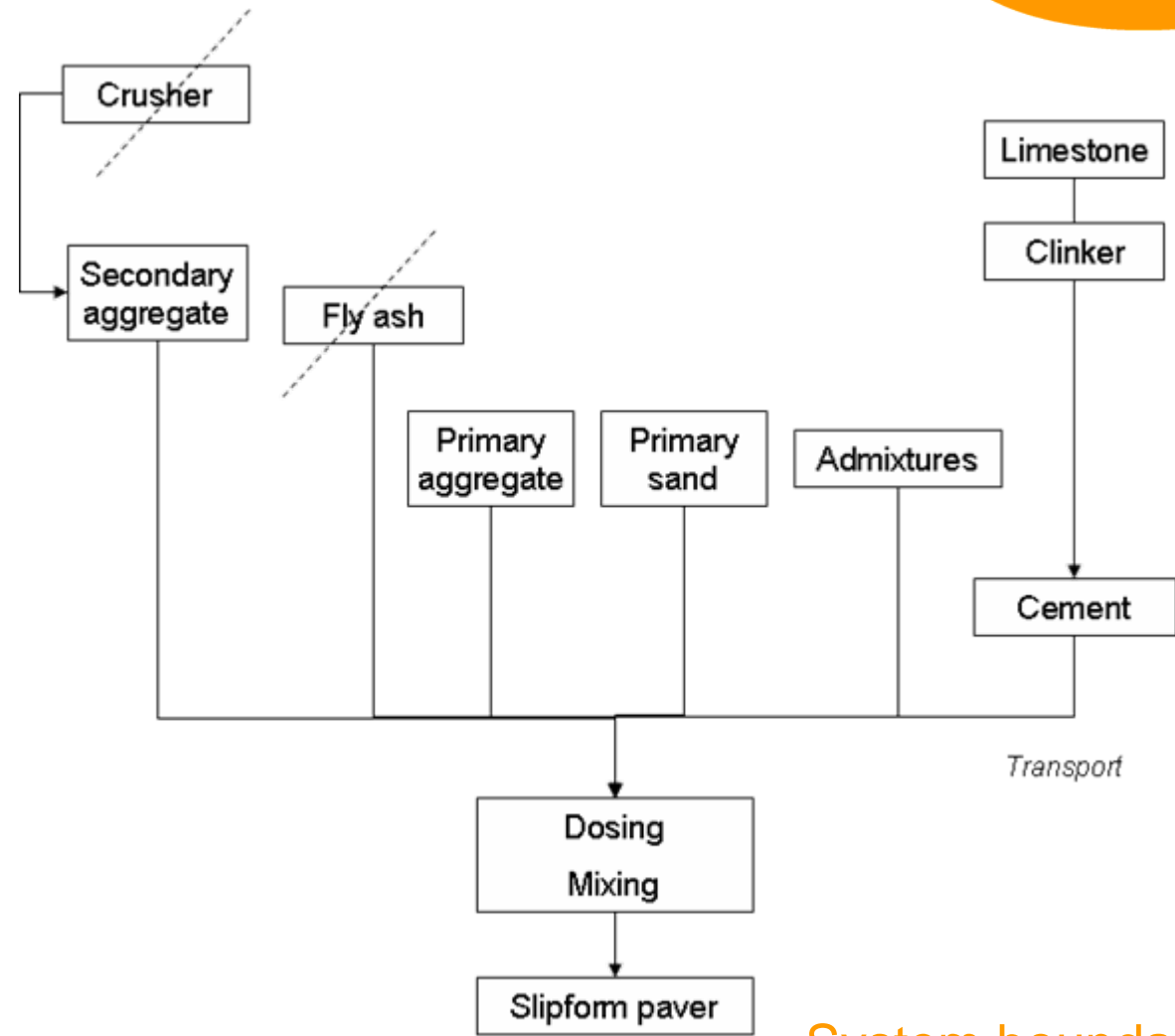


Two-lift Kansas

Functional unit

The material acquisition and construction of 1 km of a two lane highway with a total width of 7.4 m according to KDOT requirements in Kansas





- - - = allocation applied

System boundaries



Two-lift Kansas

Key differences

1. Traditional
 - Primary aggregate from OK for PCC
 - Portland cement
2. Two-lift (same plus)
 - CTB secondary aggregates on-site crusher
 - Part fly ash in CTB and top lift
3. Optimized two-lift (same plus)
 - CTB and bottom lift on-site crusher
 - Fly ash in bottom lift



Two-lift Kansas

Limitations

- Average European data for materials, processes, allocation parameters
- “just” material acquisition and construction

➔ Look for relative differences not numbers

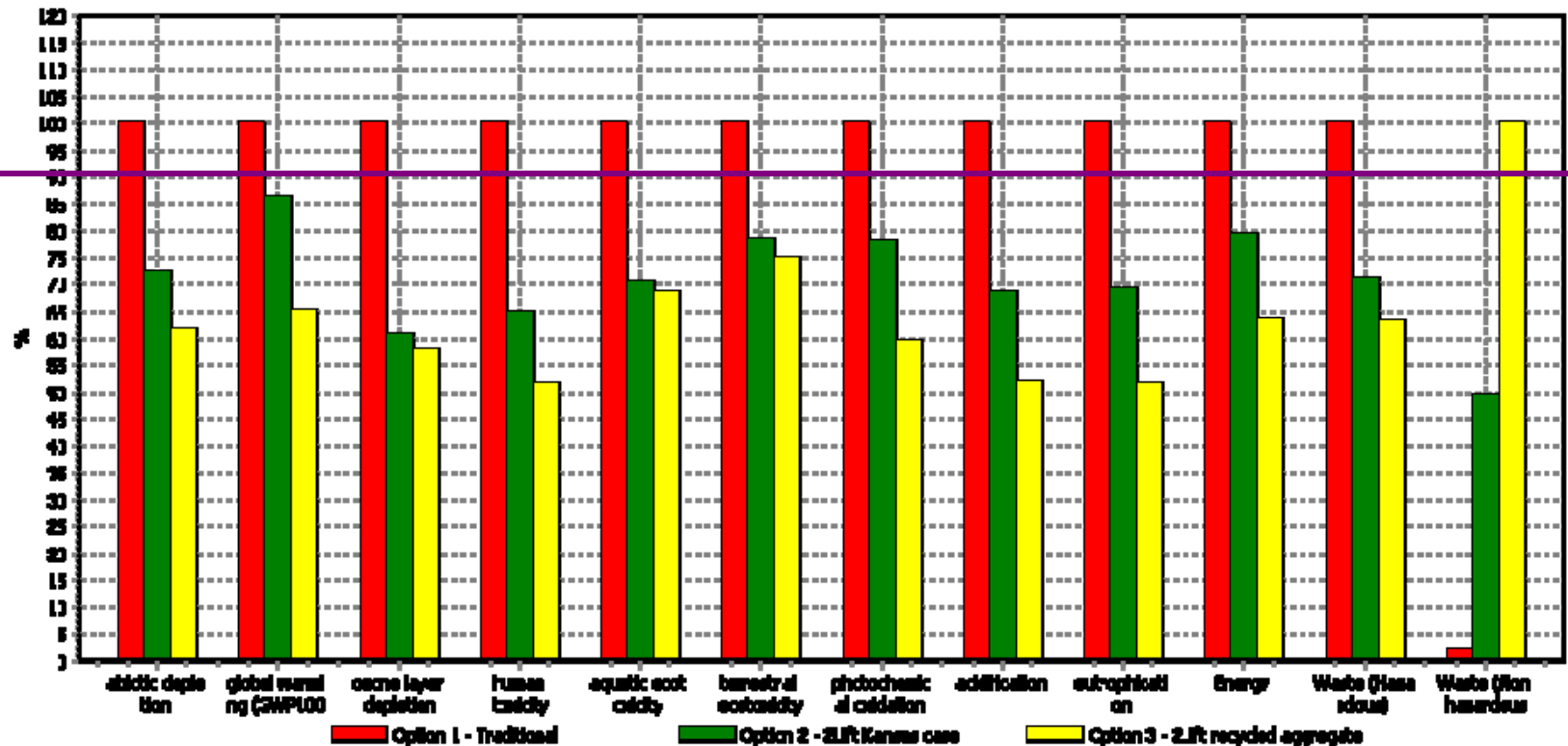


Comparison

1. Traditional

2. Two-lift

3. Optimized

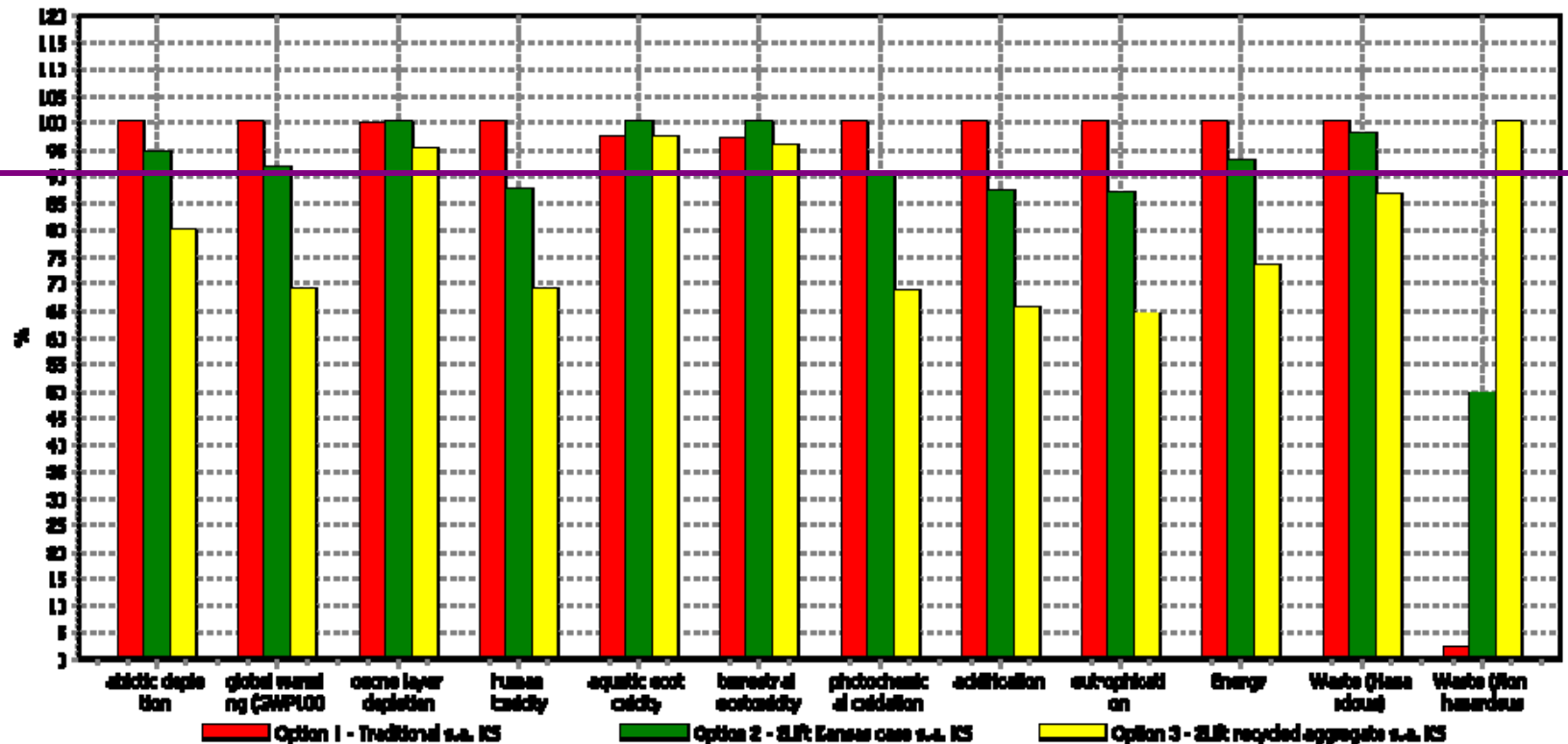


Comparing 1 p 'Option 1 - Traditional', 1 p 'Option 2 - 2Lift Kansas case' and 1 p 'Option 3 - 2Lift recycled aggregate' Method: WU:2005-NEW:2006; adapted by INTECH 8308 72.01 / World, 2000 / chenc

Sensitivity analysis

All primary aggregates local

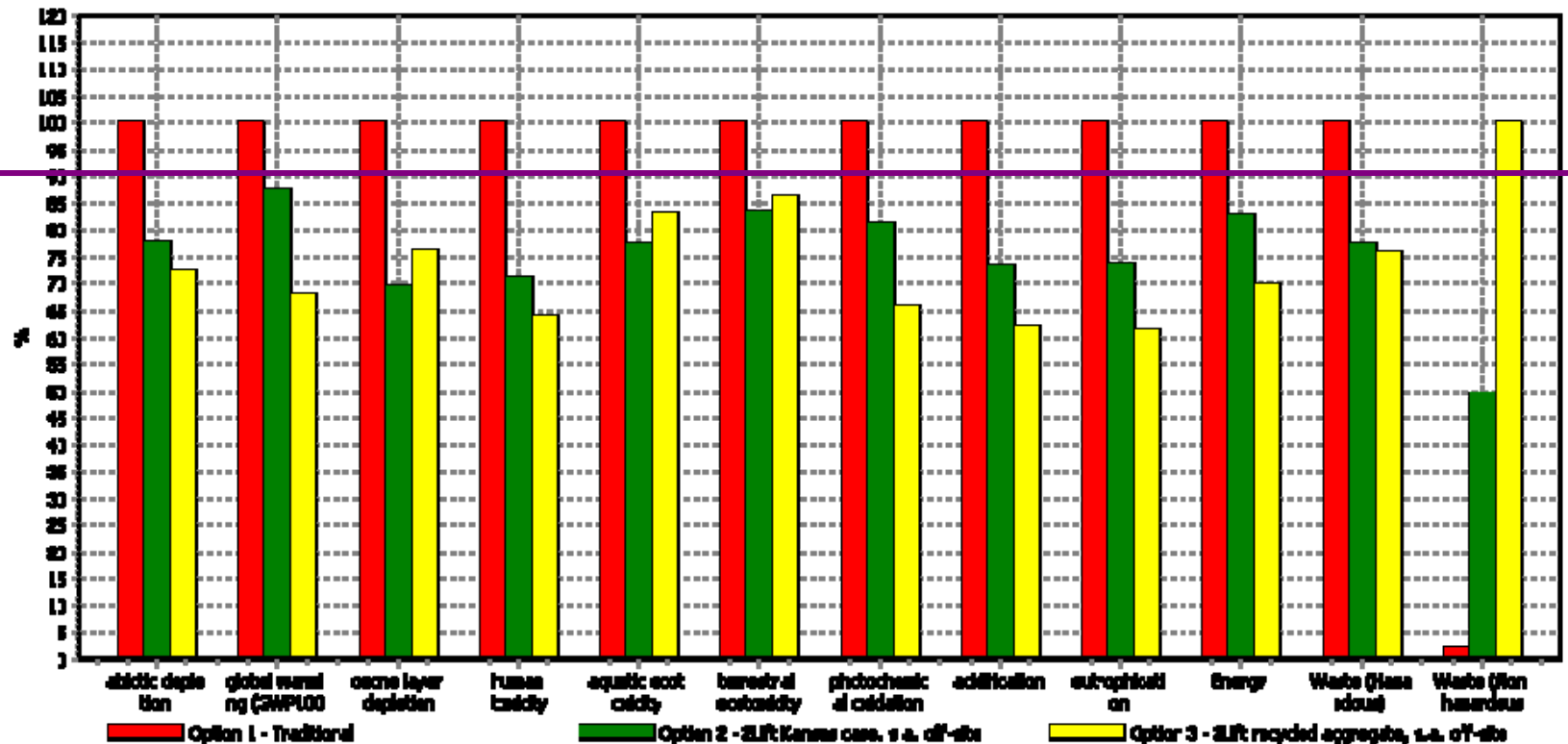
Significant



Comparing 1 p 'Option 1 - Traditional s.a. KS', 1 p 'Option 2 - 2Lift Kansas case s.a. KS' and 1 p 'Option 3 - 2Lift recycled aggregate s.a. KS'. Method VUC2005-HEM2005a adopted by INTRON 0308 V2.04

Sensitivity analysis

All recycling off-site

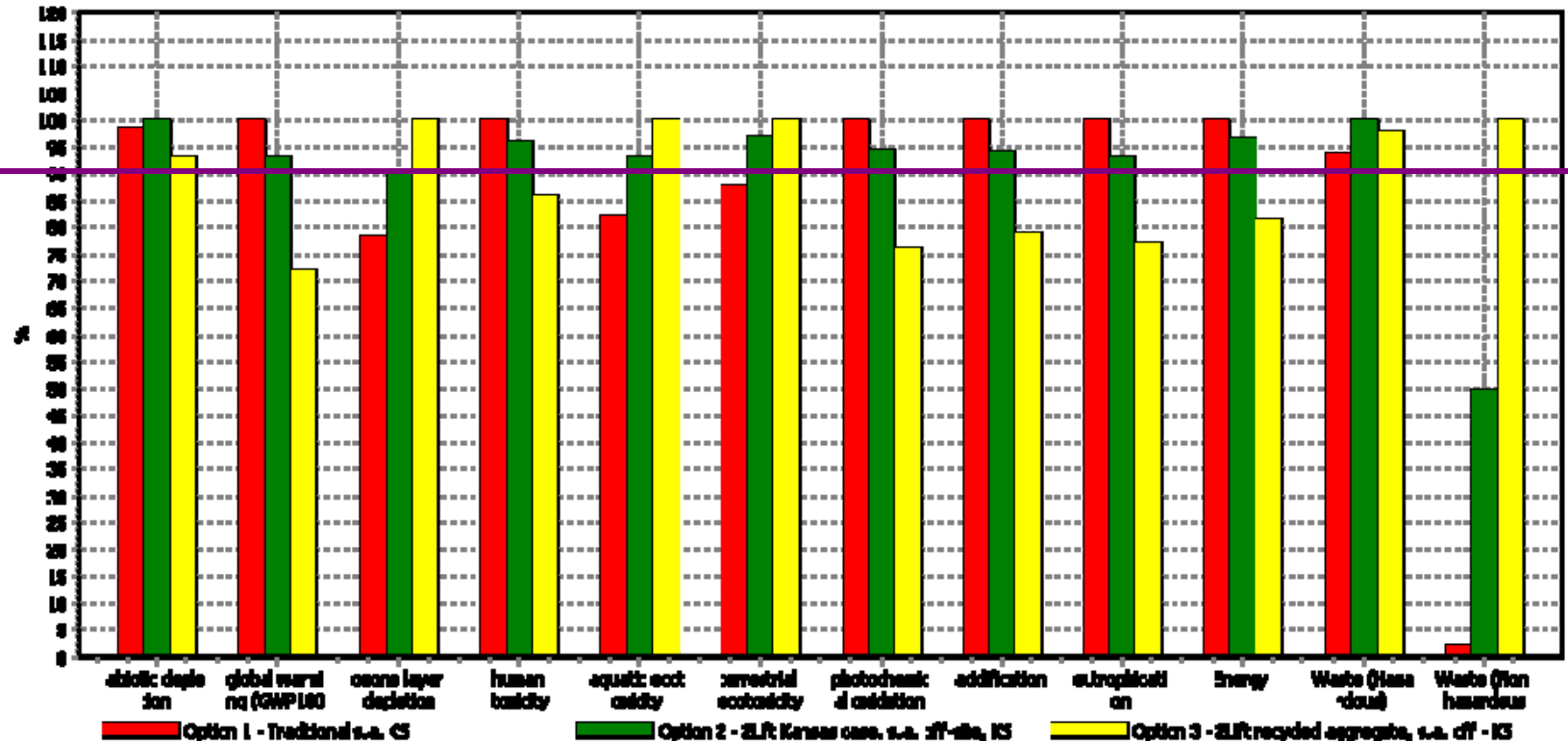


Comparing 1 p Option 1 - Traditional, 1 p Option 2 - 2Lift Kansas case, s.a. off-site and 1 p Option 3 - 2Lift recycled aggregate, s.a. off-site Method: VCA2005-REM2006; adapted by INTRON 0308V2.

Significant

Sensitivity analysis

All recycling off-site and local primary aggregates



Comparing Option 1 - Traditional s.a. KS, Option 2 - 2Lift Kansas case. s.a. off-site, KS and Option 3 - 2Lift recycled aggregate, s.a. off-site, KS; Method: VUCA2005-NEW2006 adopted by BTR

Conclusions

- Two-lift shows great potential
- Reducing clinker content is a sound strategy
- Recycling pays off
- Optimizing logistics matters
- With equal distances for primary and secondary aggregates, handling proves to be discriminating



LCA related lessons

- Always look at more than 1 indicator (trade-offs)
- Do not forget we did not look at all life cycle stages (trade-offs)
- Always look for sensitivity analyses to test the robustness of certain parameters or assumptions



Next steps

Gain experience, learn the language

- Develop a framework
- Expand on current efforts to make a concrete and cement US database
- Feed with primary data
- Perform case studies
- Make this “just” part of design

➔ Making informed decisions on a quantitative basis





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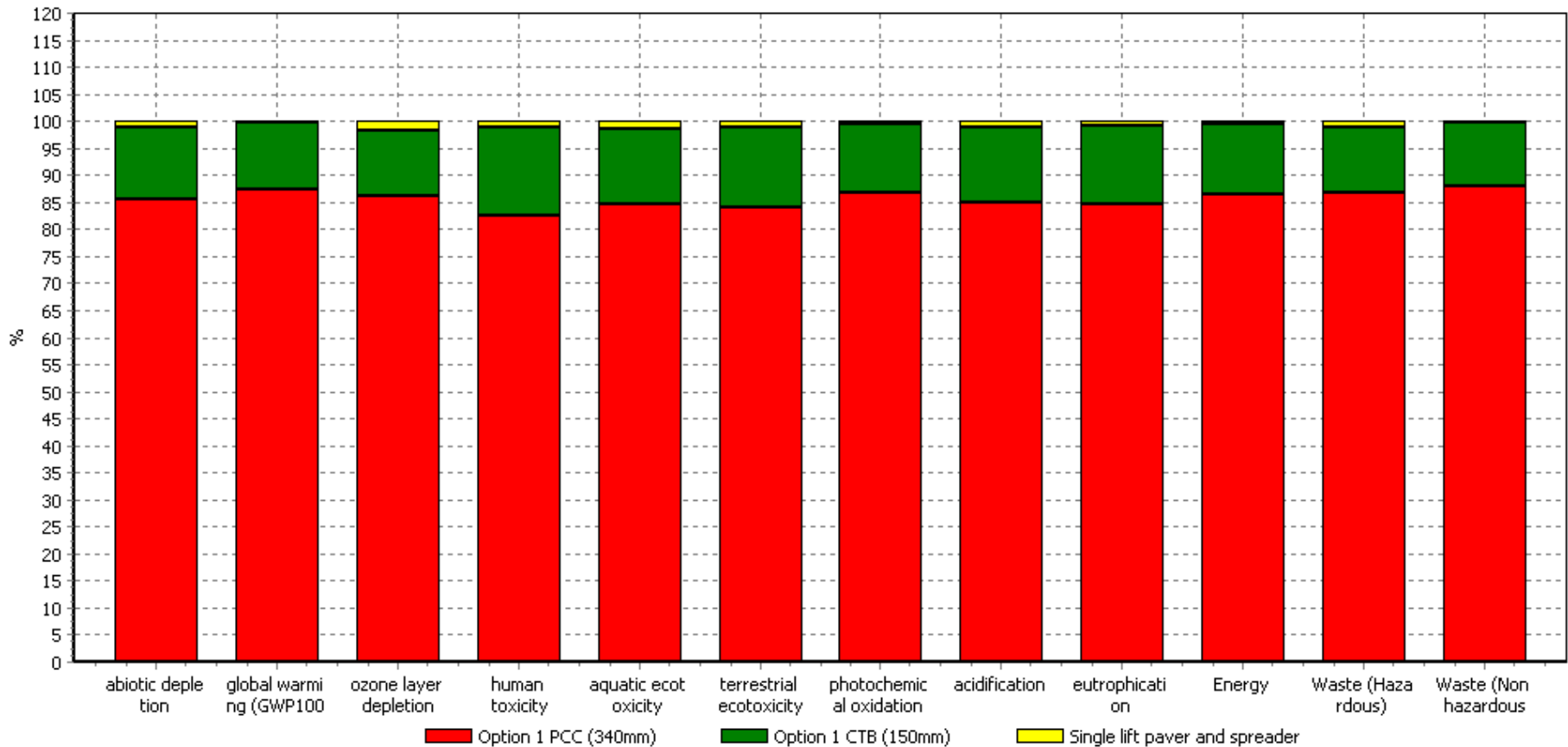
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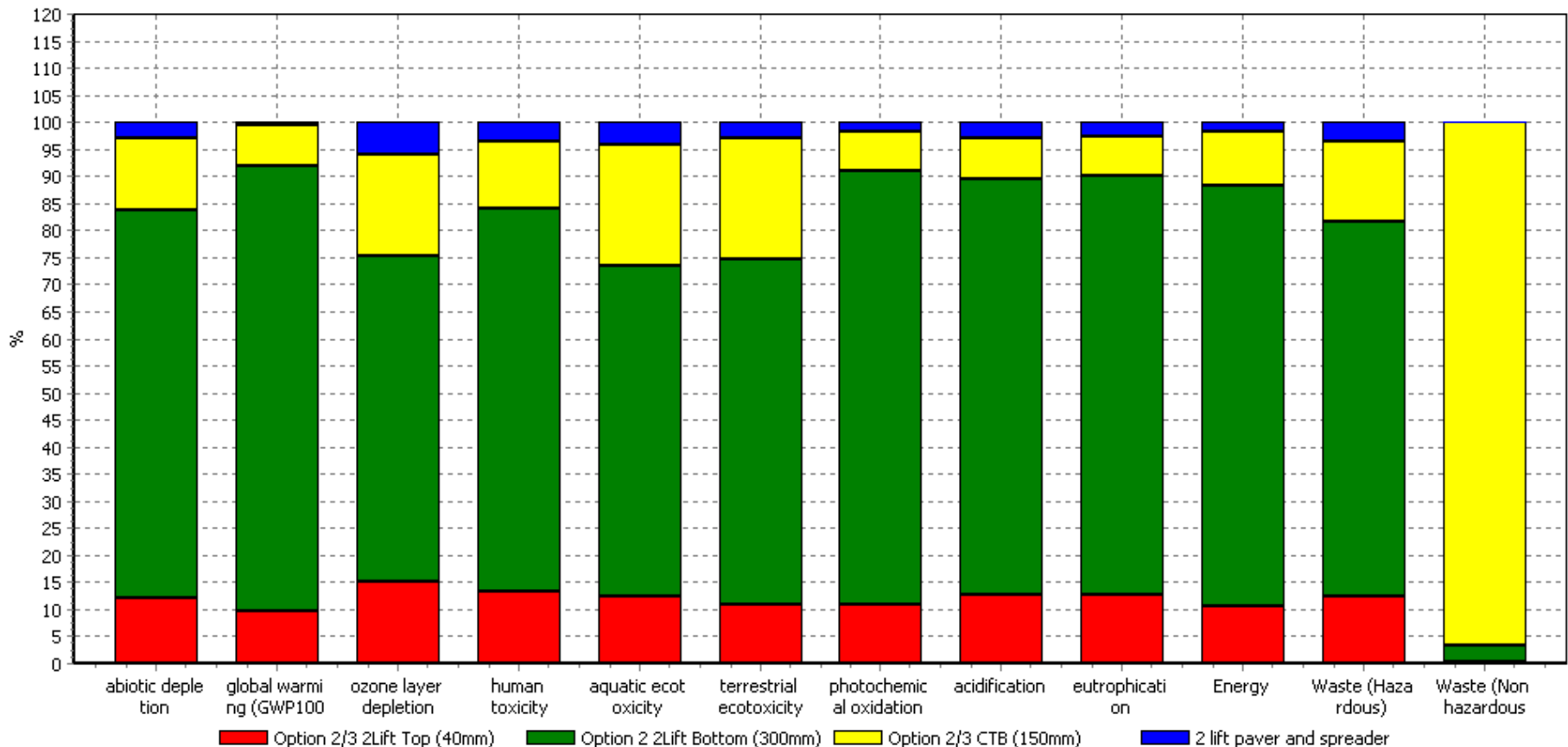
Back-up slides

Traditional



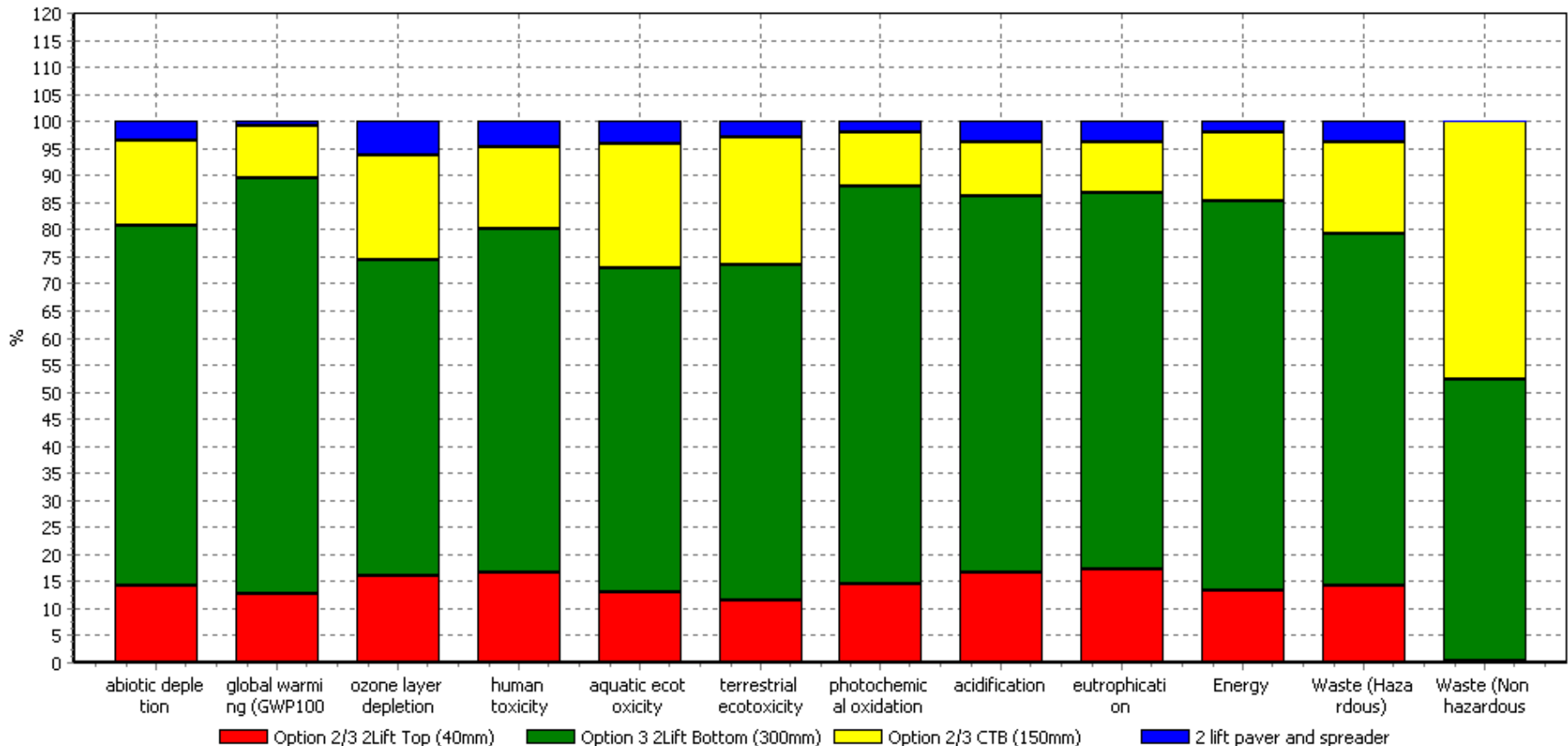
Analyzing 1 p 'Option 1 - Traditional'; Method: VLCA2005-NEN8006: adapted by INTRON 0308 V2.04 / World, 2000 / characterization

Two-lift



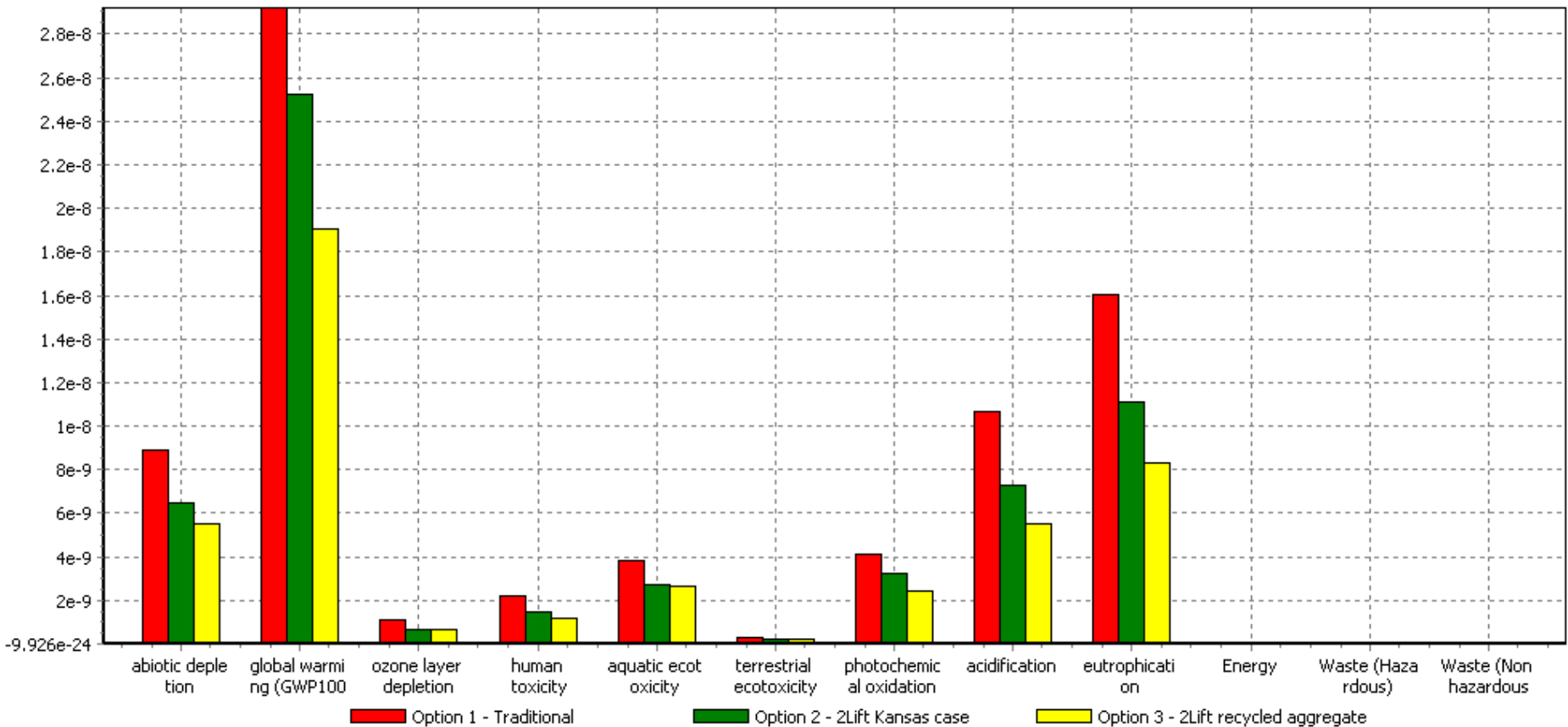
Analyzing 1 p 'Option 2 - 2Lift Kansas case'; Method: VLCA2005-NEN8006: adapted by INTRON 0308 V2.04 / World, 2000 / characterization

Optimized



Analyzing 1 p 'Option 3 - 2Lift recycled aggregate'; Method: VLCA2005-NEN8006: adapted by INTRON 0308 V2.04 / World, 2000 / characterization

Normalization



Comparing 1 p 'Option 1 - Traditional', 1 p 'Option 2 - 2Lift Kansas case' and 1 p 'Option 3 - 2Lift recycled aggregate'; Method: VLCA2005-NEN8006; adapted by INTRON 0308 V2.04 / World, 2000 / normal