Evaluation and Decision Process for Greener Asphalt Roads

Workshop

1. Methodology & Indicator selection — Matthew Wayman (TRL)
2. Test cases & Assessment tools — Johan Maeck (BRRC)
3. Multiple Attribute Decision Making — Nicolas Bueche (EPFL)

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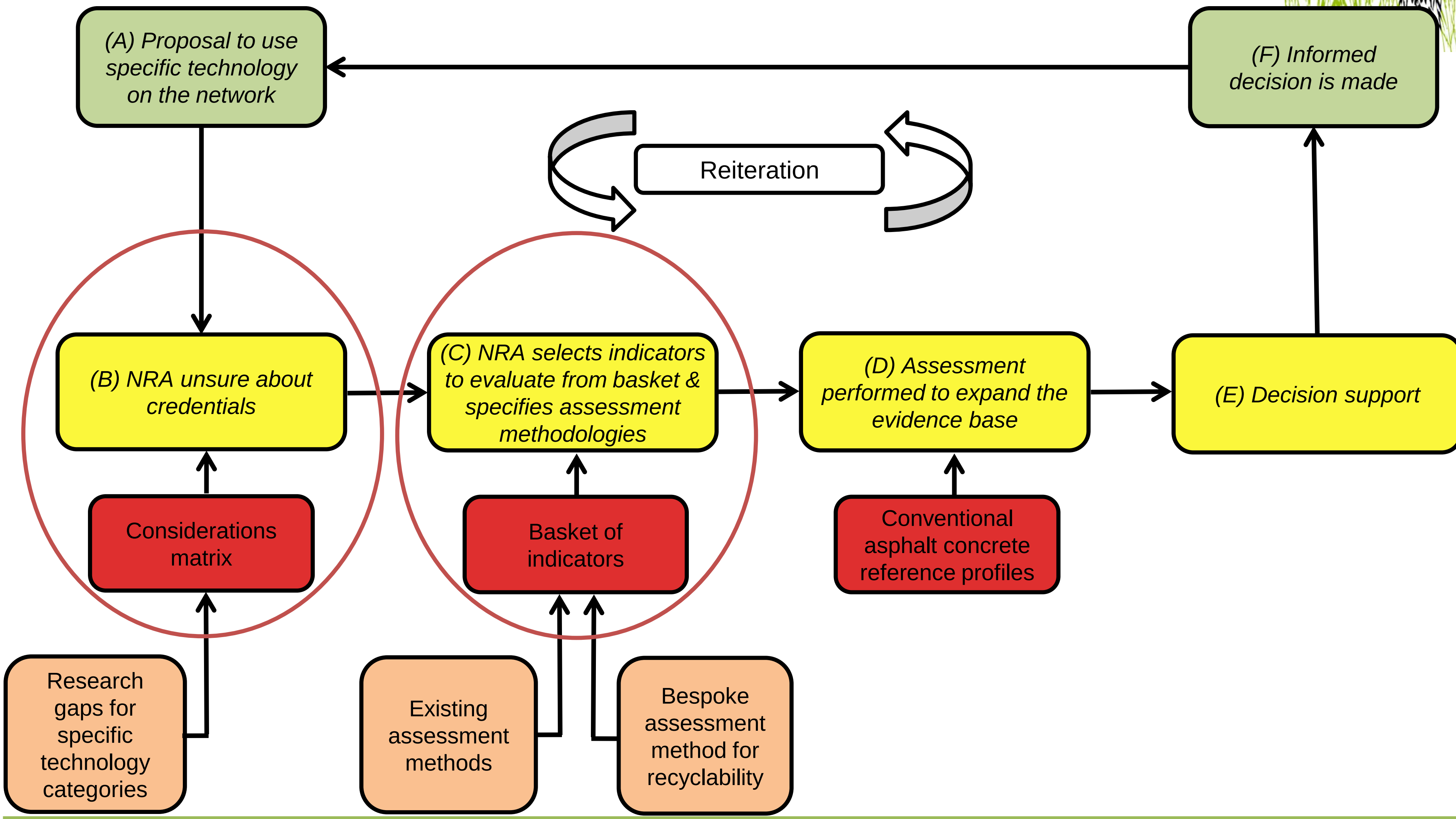
The EDGAR Methodology

- Motivation
  - The asphalt industry is not short of innovation: recycled materials, lower-temperature materials, green binders, additives…
  - Sometimes these are not adopted as quickly as they could be
  - The EDGAR methodology seeks to facilitate informed decision making over the use of new technologies
    - Quick & easy assessment
    - Quicker adoption
    - Leading to improved sustainability performance

How does the method work?



Deciding what to assess

(B) NRA unsure about a new technology's credentials

Identifying the particular concerns with a new technology…

- ⇨ The 'Considerations Matrix' can assist here
  - ⇨ Different potential 'issues' have been identified against different families of asphalt technology
  - ⇨ Based on an extensive literature review

Technologies / Applicable sustainability indicator(s)	Global warming potential	Depletion of resources & waste management	Air pollution	Leaching potential	Noise	Skid resistance	Financial cost	Recyclability	Performance (durability)	Responsible sourcing	Traffic congestion
Secondary and open-loop recycled materials											
Steel slag	♠	♣	♥	♠	♠	♣	♣	♠	♠	♣	♥
Fly ash	♠	♣	♥	♠	♥	♥	♣	♠	♠	♣	♥
Crumb rubber	♠	♣	♦	♠	♣	♥	♣	♠	♠	♣	♥
Shredded roofing	♠	♣	♦	♠	♠	♠	♣	♠	♠	♣	♥
Crushed glass	♠	♣	♥	♠	♠	♦	♣	♥	♠	♣	♥
Alternative and modified binders											
Bio-binders	♠	♥	♠	♠	♥	♥	♠	♠	♠	♠	♠
Sulphur	♣	♥	♦	♠	♥	♥	♠	♠	♠	♠	♠

gaps in evidence = ♠
clear negative = ♦
potential positive = ♣
anticipated neutral = ♥

Deciding what to assess

(C) NRA selects indicators to evaluate from the basket…

The basket of indicators:

- Global warming potential
- Depletion of resources
- Air pollution
- Leaching potential
- Noise
- Skid resistance
- Financial cost
- Recyclability
- Performance
- Responsible sourcing
- Traffic congestion

- These eleven indicators were selected using EN 15804
- Normalising the impacts to determine which are more significant for asphalt
  - Eutrophication and ozone layer depletion were 'dropped'
- Supplementing to make a rounded 'sustainability' assessment
  - Economic (financial cost and traffic congestion), social (skid resistance, noise, responsible sourcing) and performance aspects were included
- A CE marking (and declaration of performance against aspects such as fire resistance) already assumed

How to make the assessment

(C) NRA selects indicators to evaluate from the basket…

In relation to the specific technology, considering the specific concerns in relation to the basket of indicators, the NRA may decide to:

- ⇨ Request that the evidence gaps are filled (♠)
- ⇨ Ignore the anticipated neutrals (♥)
- ⇨ Accept or re-assess the negatives (♦)
- ⇨ Accept or re-assess the positives, to support the business case (♣)

How to make the assessment

(C) NRA selects indicators to evaluate from the basket…

As applied to a chemical additive (e.g. for warm-mix):

Evidence gaps (♠)

- Global warming potential
- Leaching potential
- Financial cost
- Recyclability
- Performance
- Responsible sourcing

Anticipated neutrals (♥)

- Depletion of resources
- Noise
- Skid resistance

Positives (♣)

- Air pollution
- Traffic congestion

How to make the assessment

(C) NRA specifies the assessment methodology…

Some are recommended as part of the methodology:

⇨ These have been selected to facilitate quick and easy assessment (mainly desk or lab-based

Global warming potential	Depletion of resources and waste	Air pollution	Leaching potential	Noise
• aspECT v4.0 (cradle-to - gate) • MIRAVEC (use)	• Indicator MD-2 from Greenroads v2.0	• ECORCE v2.0 or PaLATE	• CEN/TS 16637 leaching tests	• Laboratory drum methods

Skid resistance	Financial cost	Recyclability	Performance (durability)	Responsible sourcing	Traffic congestion
• Pendulum test	• LCCA Express 2.0	• EDGAR bespoke method	• Resistance to fatigue / rutting / water sensitivity	• BES 6001	• QUADRO

⇨ Though the final choice of method is with the user

Discussion and questions

1. Do you think such a methodology would facilitate implementation of new, more sustainable technologies?
2. Any ideas on the performance indicator, how could this be properly assessed?
3. Do we have the right set of indicators, should social and economic indicators be included?
4. At what time would an assessment be most useful?
   - In a pre-approval scheme
   - Alongside scheme design
   - At another time (please specify)
5. Can you think of any technologies that would immediately benefit from an assessment?

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Test cases

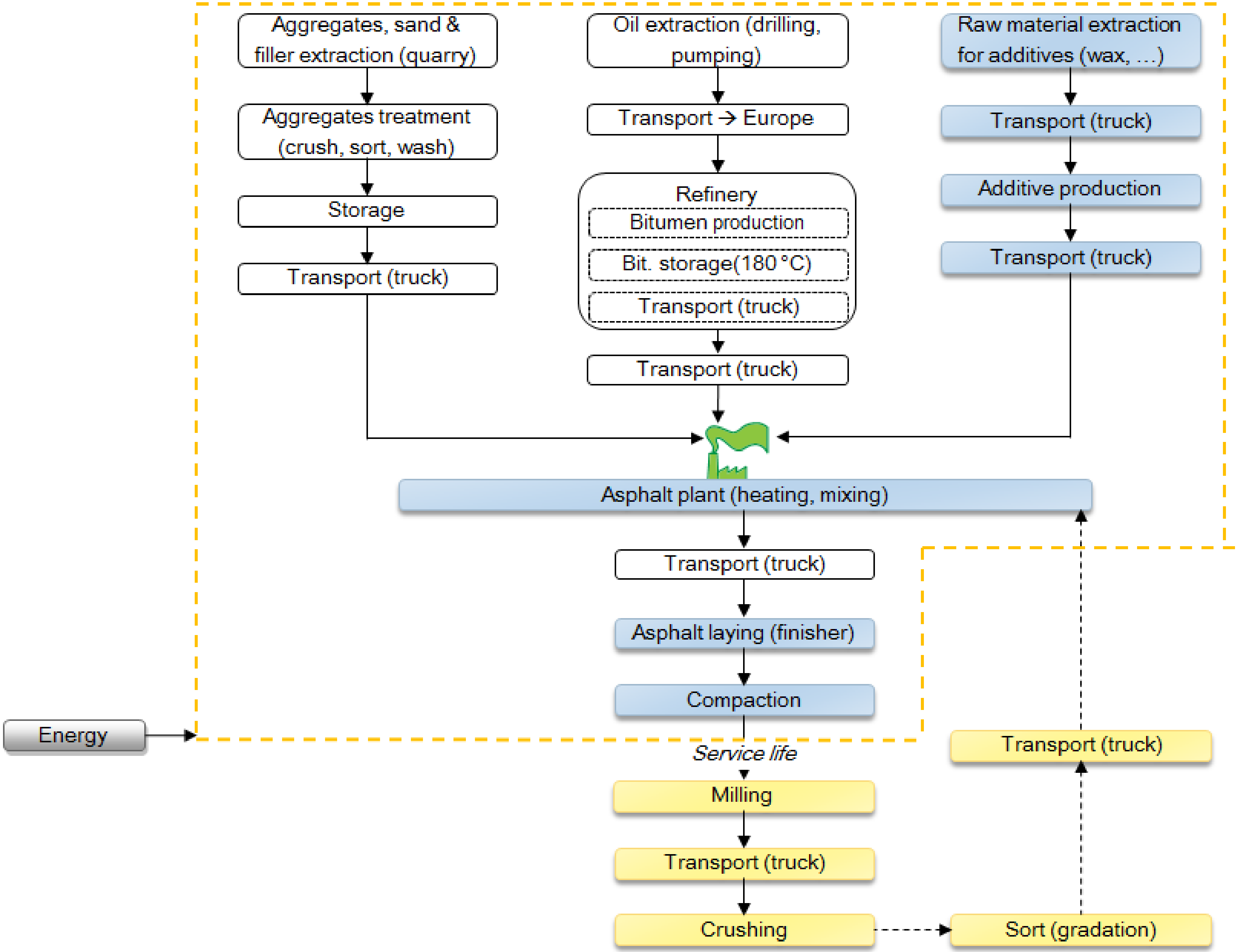
chosen for applying the methodology, based on

- **relevance & importance** of test cases for today's practice
- evidence of a **potential impact** of test cases on sustainability
- **availability of data** needed to assess the basket of selected indicators

Case study: AC-10 surface course

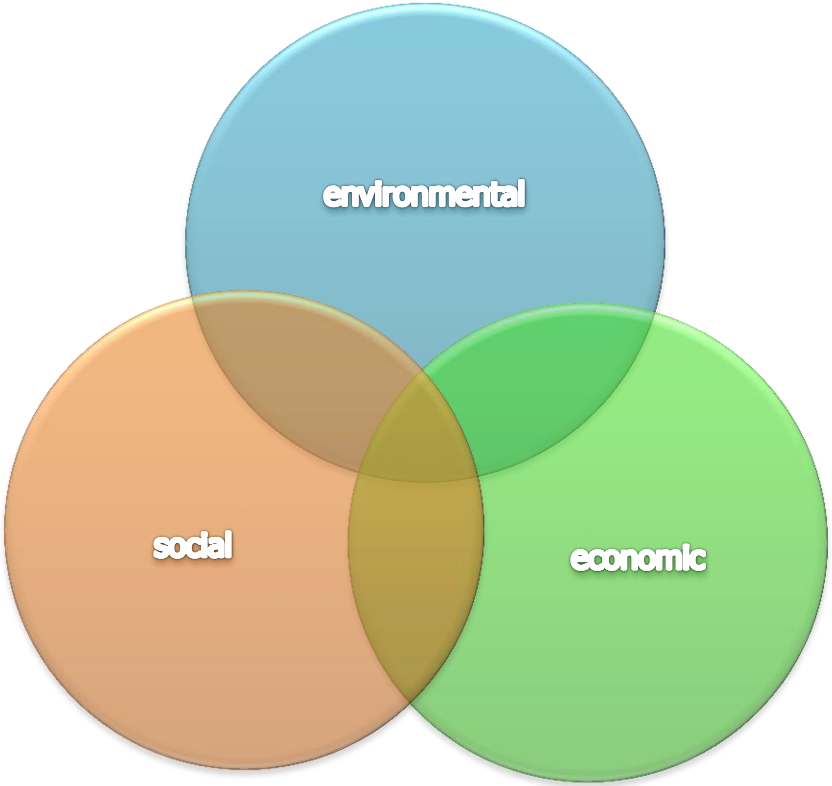
Case 1: **HMA (reference)**	paving grade bitumen (70/100) 6,2% transport modes – distances: boat vs road; return trips traffic congestion & cost model data life time of 10 y
Case 2: **WMA**	Case 1 + mixing at 130 ° C (instead of 160 ° C): fuel gain 3 m% wax on bitumen reduction of road closure duration
Case 3: **WMA with RA**	Case 2 + 30% RA
Case 4: **CIR**	on site recycling foam technology with 1% cement extended road closure duration
Case 5: **HMA with steel slag**	Case 1 + steel slag aggregates (instead of porphyry) 10% heavier: transport same binder content

Life cycle based analysis



Indicators

- Global warming potential
- Depletion of resources
- Air pollution
- Leaching potential
- Noise
- Skid resistance
- Financial cost
- Recyclability
- Performance
- Responsible sourcing
- Traffic congestion



Indicators

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- expressed in CO_2e according to EN15804
- assessment: asPECT
- bitumen (190kg CO_2e/tonne), synthetic wax carbon footprint (5700kg CO_2e/tonne), cement (913kg CO_2e/tonne)
- steel slags: no carbon footprint
- transport trucks considered empty (at lower fuel consumption) for return trip
- estimated 1 L less for WMA production
- traffic emissions based on 10 years , average traffic of 6000 cars/day & 1000 trucks/day

CO2e

GWP in different life stages

Stage	1 - HMA	2 - WMA	3 - WMA with RA	4 - CIR	5 - HMA with steel slag
A1-raw materials	16.9	26.8	21.8	18.0	13.9
A2-transport to plant	5.5	5.5	4.2	0	6.2
A3-production in plant	22.3	19.1	19.1	2.3	22.3
A4-transport to worksite	5.8	5.8	5.8	3.4	6.4
A5-laying	1.2	1.2	1.2	1.2	1.2
B1-road use	1.97e4	1.97e4	1.97e4	1.97e4	1.97e4
B2-4-maintenance	0	0	0	0	0
C1-demolition	3.1	3.1	3.1	3.1	3.1
C2-waste transport	5.8	5.8	5.8	5.8	6.4
C3-waste processing for recycling	2.0	2.0	2.0	2.0	2.0
C4-waste disposal	0	0	0	0	0
Total (excluding B1)	62.7	69.4	63.1	33.5	59.6

- materials & production & recycling
- use stage
- transport

Indicators

- Global warming potential
- Depletion of resources
- Air pollution
- Leaching potential
- Noise
- Skid resistance
- Financial cost
- Recyclability
- Performance
- Responsible sourcing
- Traffic congestion

Bitumen
Gas
Fuel

assessment: Guinée J., van Oers L. (2002)

Indicators

- Global warming potential
- Depletion of resources
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- Financial cost
- Recyclability
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- Responsible sourcing
- Traffic congestion

Production
Transport

assessment tool: ECORCE

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Indicators

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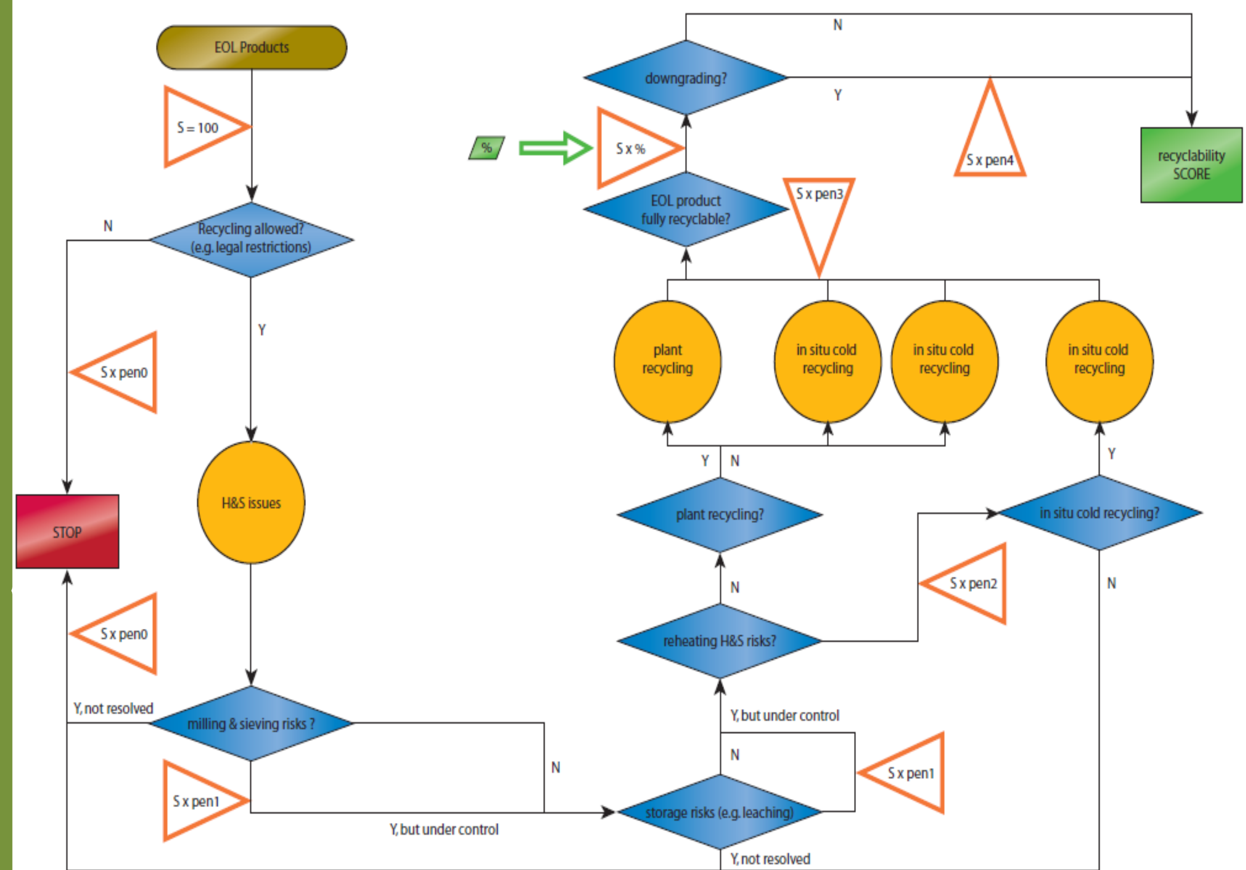

Indicators

- Global warming potential
- Depletion of resources
- Air pollution
- Leaching potential
- Noise
- Skid resistance
- Financial cost
- Recyclability
- Performance
- Responsible sourcing
- Traffic congestion

Performance testing:

- Rutting
- Water sensitivity
- Fatigue
- Ravelling

Indicators

- Global warming potential
- Depletion of resources
- Air pollution
- Leaching potential
- Noise
- Skid resistance
- Financial cost
- Recyclability
- Performance
- Responsible sourcing
- Traffic congestion

- responsible sourcing policy
- material traceability through supply chain
- H&S management systems in the supply chain
- local communities (e.g. jobs)
- …

assessment method: BRE Standard BES 6001 for Responsible Sourcing

Indicators assessed for all cases

EDGAR

Indicators		Sub-indicators		Unit	1 HMA	2 WMA	3 WMA+ RAP	4 CIR	5 HMA + steel slag
C1	GWP/Climate change			kg CO2eq	62.6815	69.36	63.055	33.5	59.626
C2	Depletion of resources			kg sbeq/tonne	2.22E-04	2.13E-04	1.54E-04	8.91E-05	2.23E-04
C3	Air pollution	C3.1	Acidification	kg SO2eq	1.27E-01	1.25E-01	1.17E-01	3.35E-02	8.16E-02
		C3.2	Photochemical oxidant formation	kgEthene eq	7.93E-02	7.81E-02	7.28E-02	1.74E-02	5.23E-02
C4	Leaching potential			-	4.33e-7	-	-	-	1.06e-6
C5	Noise			dB	95.2	95.2	95.2	-	91.7
C6	Skid resistance			BPN	65	65	70	-	62
C7	Financial cost			€	189	190	154	183	185
C8	Recyability			-	100%	100%	80%	72%	80%
C9	Performance	C9.1	Resistance to rutting	%	6%	5%	5%	6%	5%
		C9.2	Resistance to fatigue	[10-6]	115	120	120	103.5	115
		C9.3	Water sensitivity	%	90%	87%	90%	77%	90%
C10	Responsible sourcing			-	33	33	33	33	33
C11	Traffic congestion			€	23.84	18.3	18.3	55.84	23.84

Discussion and questions

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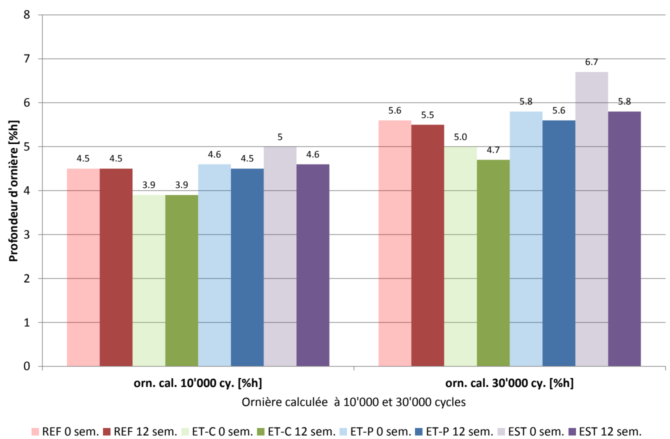
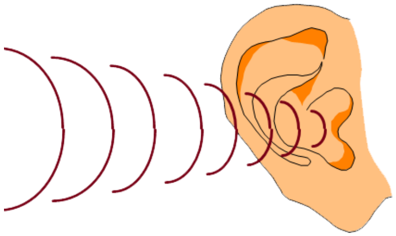
Background





How can I choose the best asphalt mixture? How to decide?

Background

- Question: Which is the best alternative between various asphalt mixtures
  1. Definition of criteria
  2. Data gathering
  3. **Global evaluation methodology** needed!

- Objective:
  - Develop a methodology that **helps in the decision making** between different asphalt mixtures types
  - Requirements: Progressive methodology, various parameters, (qualitative / quantitative), flexibility, sensitivity analysis, probabilistic approach

Model overview

Input data

2 – Global Evaluation Methodology

Level 1 – Pareto analysis

- Objective: Identify the dominant processes for each alternative and criteria
- Data: Raw and normalized performance indicators
- Criteria: GWP, depletion of resources, air pollution - LCA
- Method: Pareto analysis

Level 2 – Graphical analysis

- Objective: Identify potential alternative outranking
- Data: Raw and normalized performance indicators
- Criteria: All criteria
- Method: Graphical analysis and radar diagram

Level 3 – Partial agregation

- Objective: Alternatives ranking
- Data: Raw
- Criteria: All criteria
- Method: Partial aggregation (**Electre III**)

Level 4 – Complete agregation

- Objective: Alternatives ranking
- Data: Raw
- Criteria: All criteria
- Method: Complete aggregation (**Evidential reasoning approach**)

DECISION AID (asphalt mixture type)

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Input for MADM: Case study

Indicators		Sub-indicators		Unit	1 HMA	2 WMA	3 WMA+ RAP	4 CIR	5 HMA + steel slag
C1	GWP/Climate change			kg CO2eq	62.6815	69.36	63.055	33.5	59.626
C2	Depletion of resources			kg sbeq/tonne	2.22E-04	2.13E-04	1.54E-04	8.91E-05	2.23E-04
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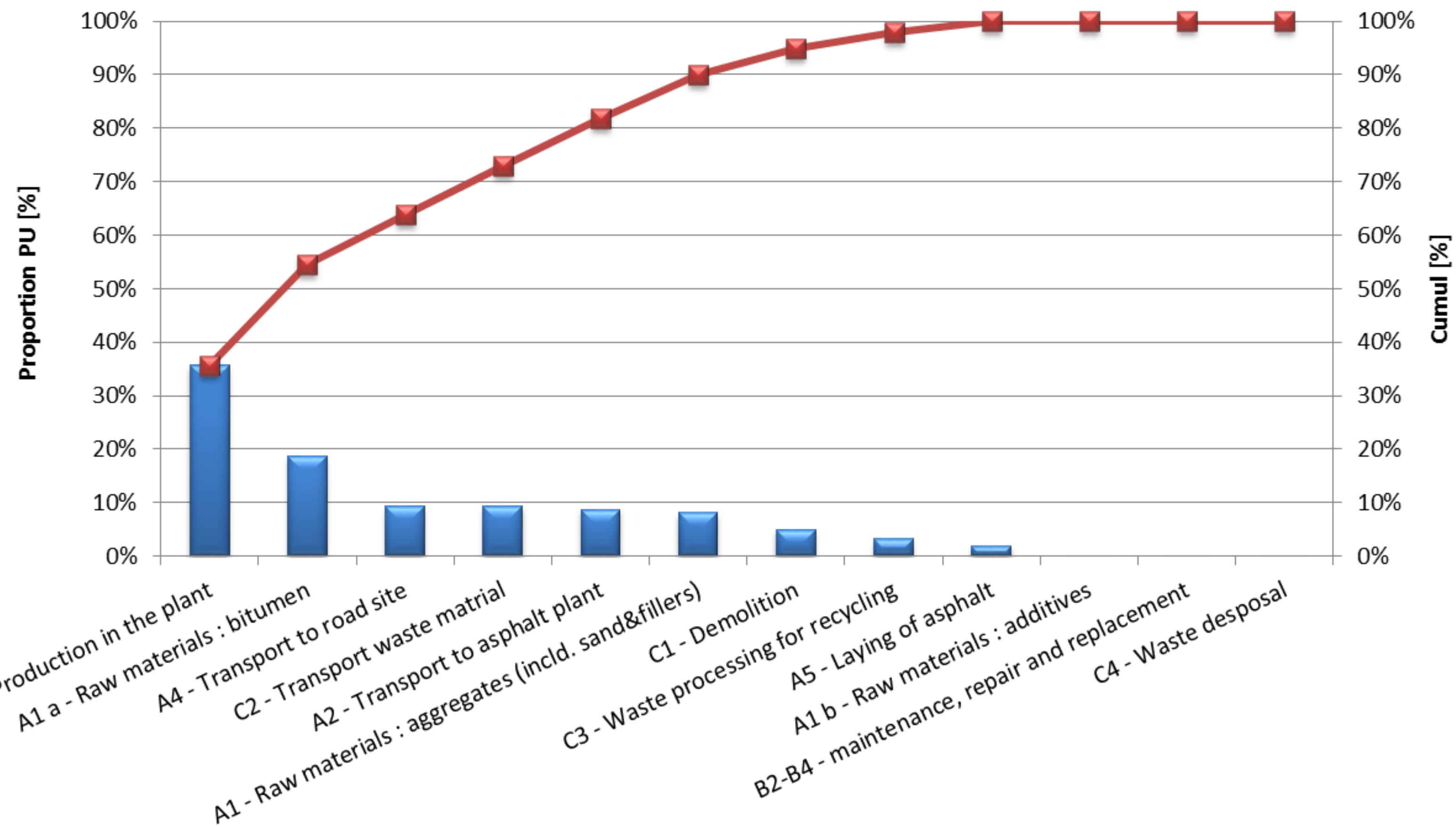
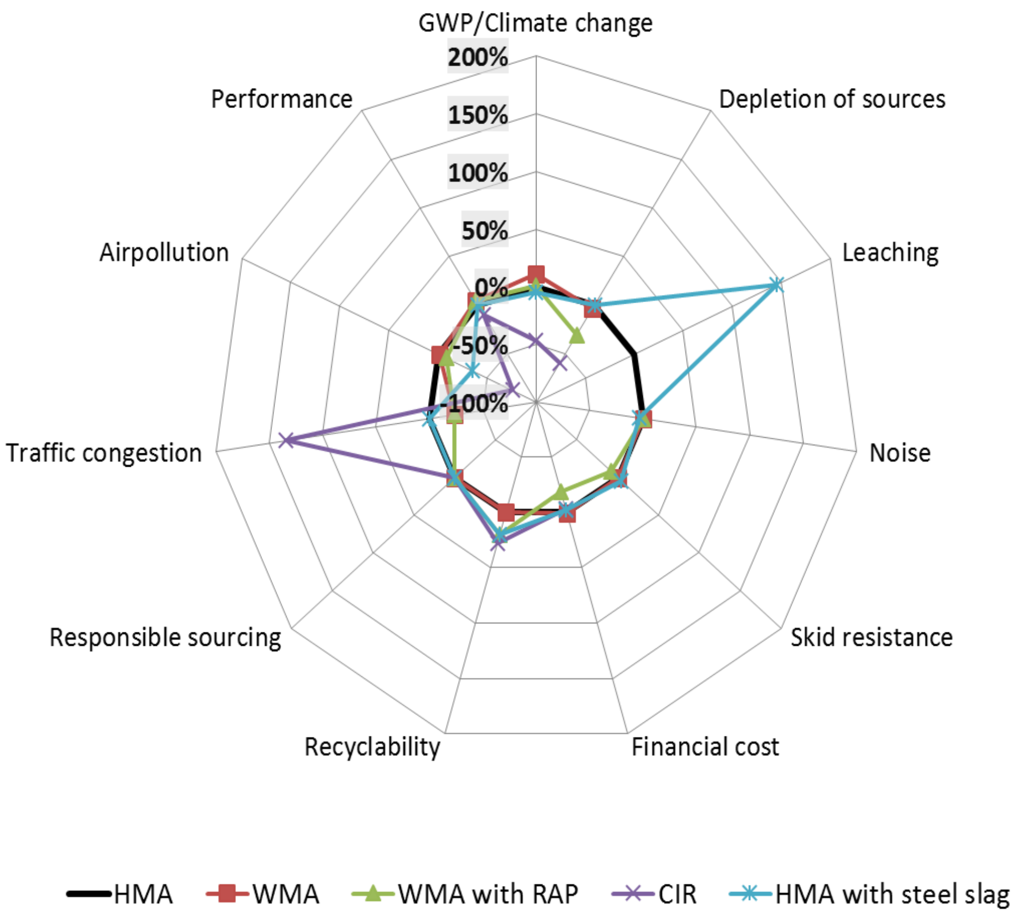
		C3.2	Photochemical oxidant formation	kgEthene eq	7.93E-02	7.81E-02	7.28E-02	1.74E-02	5.23E-02
C4	Leaching potential			-	4.33e-7	-	-	-	1.06e-6
C5	Noise			dB	95.2	95.2	95.2	-	91.7
C6	Skid resistance			BPN	65	65	70	-	62
C7	Financial cost			€	189	190	154	183	185
C8	Recyability			-	100%	100%	80%	72%	80%
C9	Performance	C9.1	Resistance to rutting	%	6%	5%	5%	6%	5%
		C9.2	Resistance to fatigue	[10-6]	115	120	120	103.5	115
		C9.3	Water sensitivity	%	90%	87%	90%	77%	90%
C10	Responsible sourcing			-	33	33	33	33	33
C11	Traffic congestion			€	23.84	18.3	18.3	55.84	23.84

Level 1: Pareto analysis

- GWP, Hot Mix Asphalt



Level 2: Graphical analysis



Level 3: Partial aggregation

- Weighting

N°	Indicator	ω	Weighting ω [0 … 1] ω_i	ω_{ij}	Final
C1	GWP/Climate change	ω_1	0.175		0.1750
C2	Depletion of resources	ω_2	0.050		0.0500
C3.1	Air pollution- Acidification	ω_{31}	0.075	0.500	0.0375
C3.2	Air pollution-photochemical oxidant formation	ω_{32}		0.500	0.0375
C4	Leaching potential	ω_4	0.050		0.0500
C5	Noise	ω_5	0.063		0.0625
C6	Skid resistance	ω_6	0.050		0.0500
C7	Financial cost	ω_7	0.088		0.0875
C8	Recyclability	ω_8	0.138		0.1375
C9.1	Performance-Resistance to rutting	ω_{91}	0.225	0.500	0.1125
C9.2	Performance-Resistance to fatigue	ω_{92}		-	-
C9.3	Performance-water sensitivity	ω_{93}		0.500	0.1125
C10	Responsible sourcing	ω_{10}	0.038		0.0375
C11	Traffic congestion	ω_{11}	0.050		0.0500
		Sum ω	1.00	Ok	1.0000
		Verification	Ok		Ok

- Thresholds

Indicator	C1	C2	C3.1	C3.2	C4	C5	C6	C7	C8	C9.1	C9.2	C9.3	C10	C11
Unit	kg CO2eq	kg sbeq/tonne	kg SO2eq	kgEthene eq	-	dB	BPN	€	%	%	%	[10-6]	-	€
q_j	1.0	1.0E-05	2.0E-03	2.00E-3	1.0e-7	0.5	1	5	0.05	0.001	2	0.05	0.5	4
p_j	5.0	3.0E-05	1.0E-02	1.00E-2	3.0e-7	1	2	10	0.10	0.01	5	0.10	1	10
v_j	50.0	3.0E-04	0.1	0.10	1.5e-5	15	20	100	1.00	1.00	50	1.00	10	100

- Results (ranking)

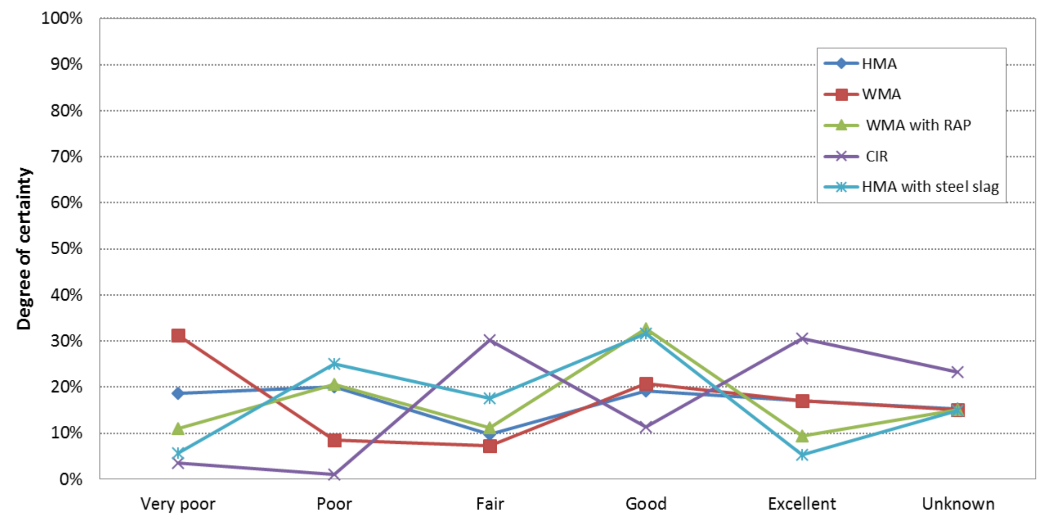
CASE	1 HMA	2 WMA	3 WMA+RA	4 CIR	5 HMA+STEEL SLAG
RANK	4	5	2	1	3

Level 4: Complete aggregation

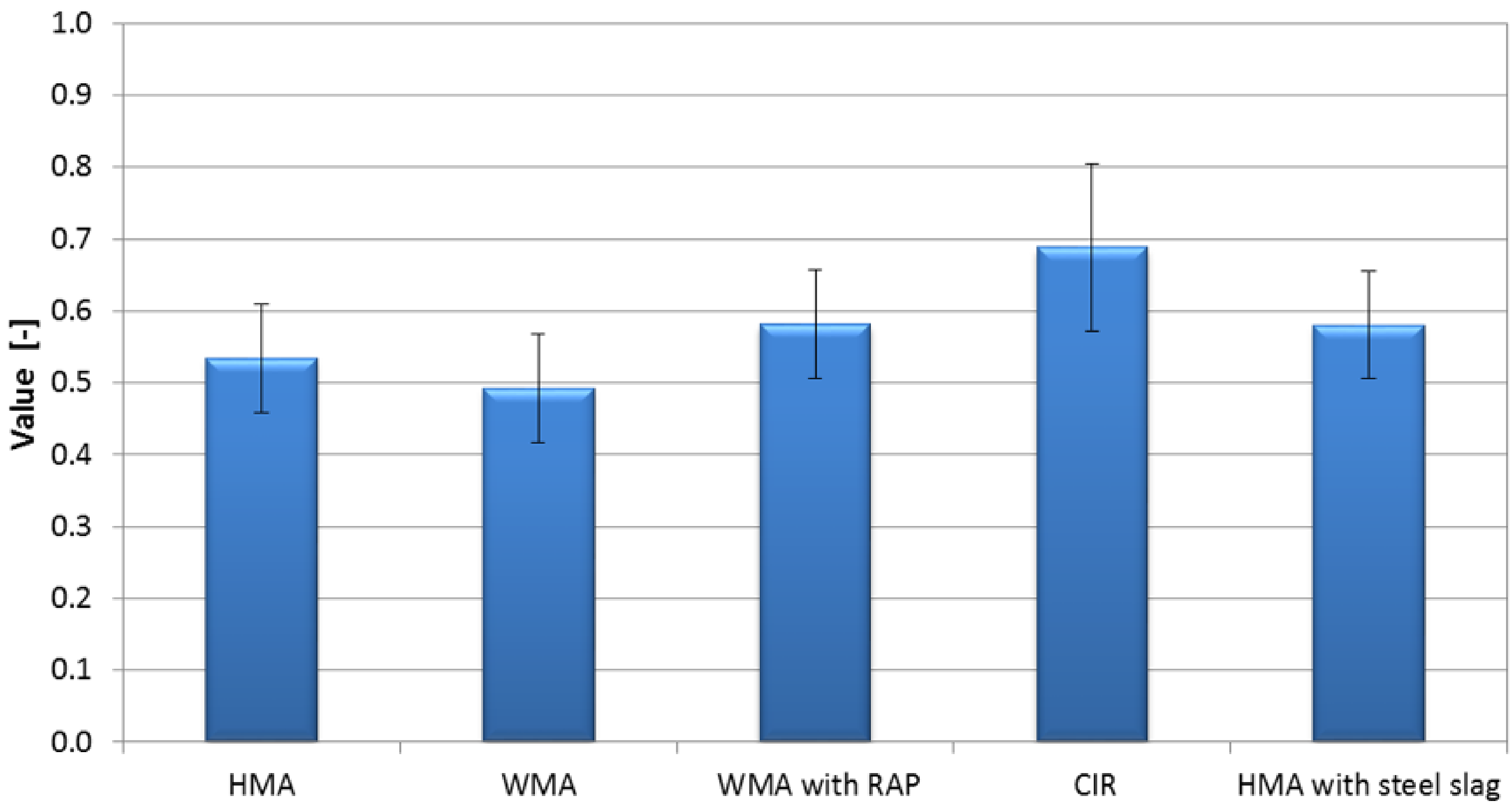
- Performance levels

	Transformation matrix - quantitative indicator													
	C1	C2	C3.1	C3.2	C4	C5	C6	C7	C8	C9.1	C9.2	C9.3	C10	C11
	kg CO2eq	-	kg SO2eq	kgEthene eq	-	dB	BPN	€	-	%	[10-6]	%	-	€
Unknown	No values is assigned													
Very poor	71	2.25E-04	1.30E-01	8.10E-02	4.40E-06	96	60	630	Qualitative	10.0%	100	70%	20	58
Poor	61.5	1.90E-04	1.05E-01	6.50E-02	3.40E-06	92	63	615		8.5%	105	75%	22	48
Fair	52	1.55E-04	8.00E-02	4.90E-02	2.40E-06	88	66	600		7.0%	110	79%	26	38
Good	42.5	1.20E-04	5.50E-02	3.30E-02	1.40E-06	84	69	585		3.5%	120	84%	30	28
Excellent	33	8.50E-05	3.00E-02	1.70E-02	4.00E-07	80	72	570		0.0%	130	88%	33	18

- Belief degree (overall performance)



Level 4: Complete aggregation



CASE	1 HMA	2 WMA	3 WMA+RA	4 CIR	5 HMA+STEEL SLAG
RANK	4	5	2	1	3

Sensitivity analysis (robustness)

- Objective: Assess solution robustness
- Process: Vary key parameters one by one and analyse consequences on final ranking

	Reference ranking		Average ranking from sensitivity analysis	
	Partial aggregation Method	Complete aggregation method	Partial aggregation Method	Complete aggregation method
HMA	4	4	4	4
WMA	5	5	5	5
WMA+RA	2	2	2	2
CIR	1	1	1	1
HMA+Steel Slag	3	3	3	3

Discussion and questions

Thank you for your participation & feedback

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