Use MCDA for decision-making in LCA

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Séminaire ScoreLCA, Paris, 16 mars 2017

Summary

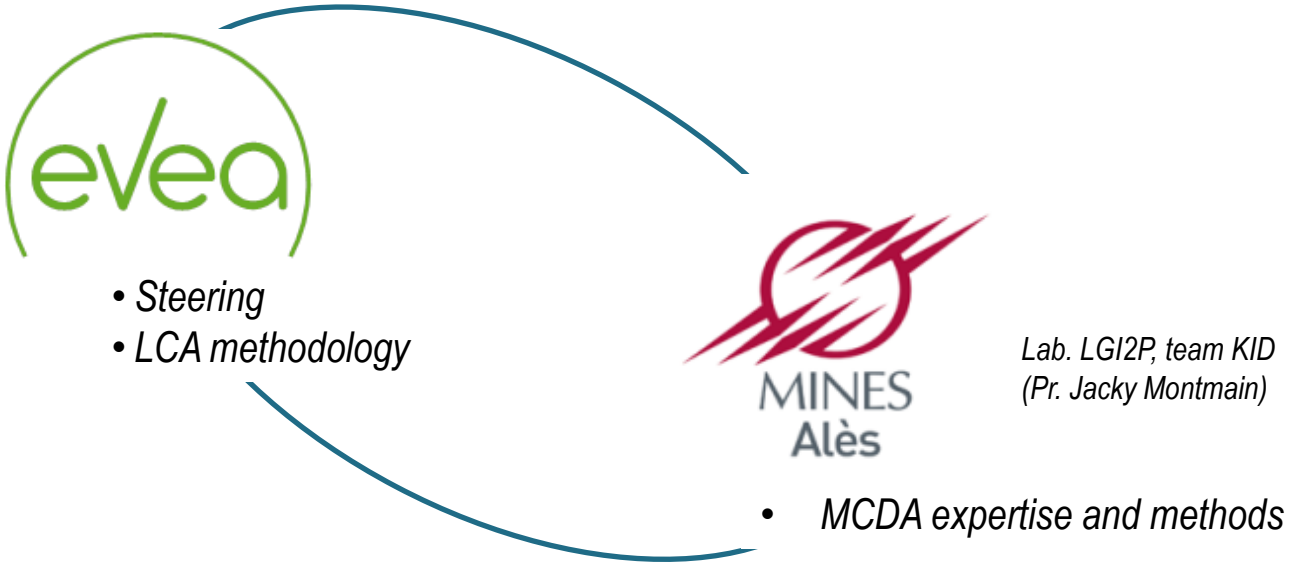
1. Context, goal, and method
2. Two key messages
3. Case study
4. Learnings and conclusion

1. Context, goal, and method

Context

– Beginning 2015 → Delivery 2016

– A partnership



Goal

STAKES

Interpretation of LCA results and aid-decision making based on multicriteria information :

- Orientation of public policies
- Decision making for design (ecodesign)
- Companie's strategic orientation
- R&D programs
- etc.

GOAL OF THE STUDY

- Reveal in what extent mathematics used for multicriteria analysis could help or resolve the treatment of LCA multicriteria information to facilitate decision making
- Explore if existing tools for MCDA could be applied to LCA and, if so, what are the prerequisites

The three steps of the study

1. **A scientific review**

   → History, schools of thought, methods and mathematical principles, typologies, etc.

   → Recommendations about the best-suited methods for LCA

2. **A case study**

   Multicriteria analysis of some LCA results wtih two recommended methods

3. **A guideline for LCA practionners and users**

2. Two key messages

Two key messages for LCA practitionners

1

The wish of an absolute and universal priorization table of environmental stakes is no more than a dream.

MCDA methods are not tailored to reveal THE real truth upon which each decision-maker could rely on.

2

The common use in the LCA community of weighting of environmental indicators to achieve a single score (weighted sum) is mathematically unfounded and does not make sense.

The LCA community should adopt less simplistic and more justifiable methods for agregation of LCA results.

3. Case study

Case study

GOAL

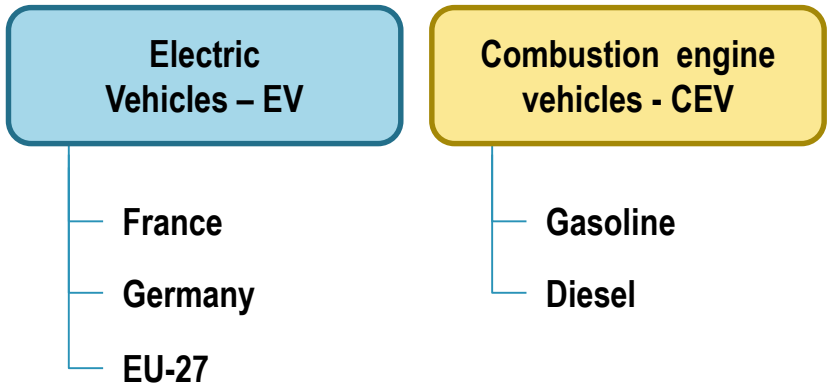
Implementation of two recommended MCDA methods with a LCA case study

LCA STUDY

Comparison of environmental impacts of electric vehicles versus combustion engine vehicles *[Ademe, 2012]*

APPLICATION

- **5 scenarios**



- **7 environmental indicators**
  - Climate change potential
  - Eutrophication potential
  - Acidification potential
  - Total energy consumption
  - Radioactive wastes
  - Radioactive emissions (air)
  - NOx emissions

Case study

Two MCDA methods for testing

2 methods from 2 differents classes :

- MACBETH *Shapley indexes and Choquet integral*
- ELECTRE III *Weighting with Simos method*

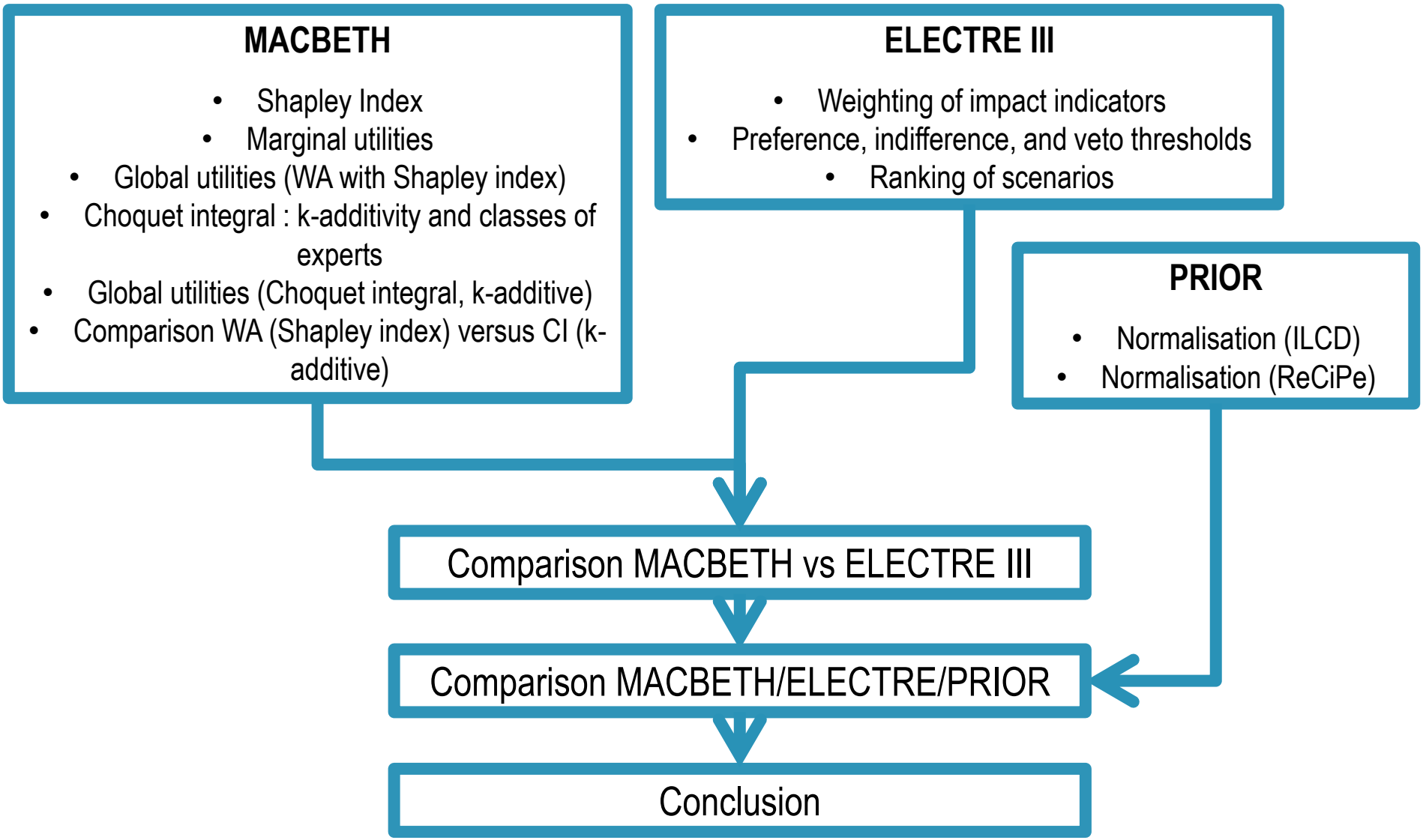
Panel of « decision-makers »

- 12 experts (LCA or environmental issues) …
- … from 7 different organisms
- Individual contributions

Questionnaire

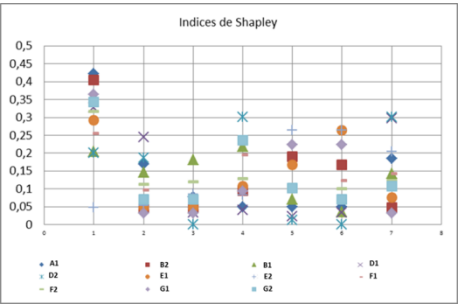
2 questionnaires (XLS files) sent by email and individually answered

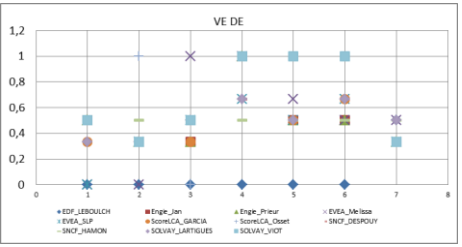
Overview of the results



Overview of the results

MACBETH





Scénario / Expert	VE DE	VE EU 27	VE FR	VT Gasoline NEDC	VT Diesel NEDC
F1	0,673501	0,640994	0,767812	0,43102	0,459544
F2	0,466457	0,544399	0,758194	0,395269	0,279363
E2	0,500238	0,515	0,45282	0,697485	0,574097
E1	0,54162	0,462531	0,533372	0,547415	0,482429
D2	0,710582	0,583828	0,987765	0,34953	0,50004
D1	0,37571	0,392121	0,943226	0,440481	0,158705
G2	0,350685	0,364853	0,826453	0,344516	0,27592
G1	0,401923	0,271436	0,520821	0,454443	0,494826
B1	0,531295	0,42931	0,894022	0,419435	0,264396
B2	0,52391	0,329508	0,642456	0,452346	0,420939
A1	0,093277	0,211686	0,85427	0,308457	0,000287

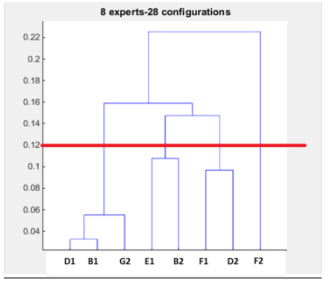


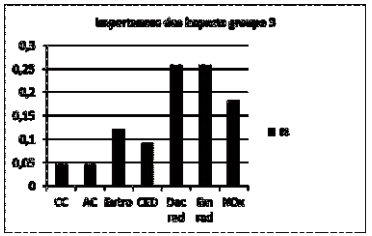
Figure 1 : Représentation du clustering pour les 8 experts avec coupure de l'arbre à 0.12

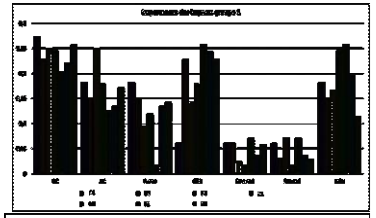
Scénarios / Experts	1 - VE DE	2- VE EU 27	3- VE FR	4- VT Gasoline NEDC	5- VT Diesel NEDC
F1	0,368689	0,210718	0,263979	0	5,28E-05
F2	0,367683	0,292482	0,324523	0,126186	0,0720442
E2	0,500165	0,444254	0	0,300566	0,159841
E1	0,483642	0,373161	0,293801	0,340709	0,24904
D2	0,642944	0,459913	0,97553	0,27547	0,401575
D1	0,363987	0,524919	0,905762	0,595174	0,191432
G2	0,457319	0,512912	0,861007	0,442842	0,337881
G1	0,417275	0,216375	0,580203	0,486585	0,534112
B1	0,619948	0,55744	0,899022	0,541752	0,336403
B2	0,42937	0,142641	0,427866	0,143171	0,213318
A1	0,087101	0,142831	0,871163	0,279131	0,000208

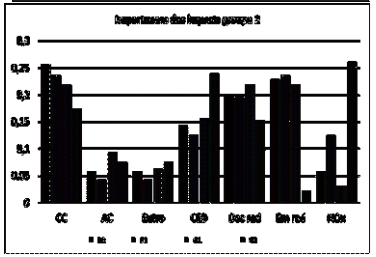
ELECTRE

Indicateurs / Experts	CC	AC	Eutro	CED	Dec rad	Em rad	NOx
A1	0,272727	0,181818	0,181818	0,0606061	0,0606061	0,0606061	0,181818
B2	0,257143	0,0571429	0,0571429	0,142857	0,2	0,228571	0,0571429
B1	0,227273	0,151515	0,151515	0,227273	0,0606061	0,030303	0,151515
D1	0,25	0,25	0,0952381	0,142857	0,0238095	0,0714286	0,166667
C1	0,244565	0,179348	0,119565	0,179348	0,0163043	0,0163043	0,244565
D2	0,203125	0,125	0,015625	0,257812	0,0703125	0,0703125	0,257812
E1	0,236111	0,0416667	0,0416667	0,125	0,194444	0,236111	0,125
E2	0,0454545	0,0454545	0,121212	0,0909091	0,257576	0,257576	0,181818
F1	0,219512	0,134146	0,134146	0,243902	0,0365854	0,0365854	0,195122
F2	0,257143	0,171429	0,142857	0,228571	0,0571429	0,0285714	0,114286
G1	0,21875	0,09375	0,0625	0,15625	0,21875	0,21875	0,03125
G2	0,173913	0,076087	0,076087	0,23913	0,152174	0,021739	0,26087

Scénarios / Experts	VE DE	VE EU 27	VE FR	VT Gasoline NEDC	VT Diesel NEDC
A1	3	2	1	5	4
B2	3	4	3	5	1
B1	1	5	3	2	4
D1	2	5	1	5	5
C1	1	5	4	4	4
D2	2	3	1	4	5
E1	3	5	4	2	4
E2	3	5	5	1	4
F1	2	5	1	4	5
F2	1	5	3	2	4
G1	3	4	4	5	1
G2	2	3	1	5	4







PRIOR

		EV-GE	EV-UE27	EV-FR	Gasoline CEV	Diesel CEV
ILCD	Score	19,98	21,74	28,53	20,17	19,77
	%	*101%*	*110%*	*144%*	*102%*	*100%*
	Rank	2	4	5	3	1
ReCiPe	Score	11,39	11,79	11,17	13,27	12,79
	%	*102%*	*106%*	*100%*	*119%*	*115%*
	Rank	2	3	1	5	4

Most contributing indicators (by order of importance)

ILCD:
1. *RE air*
2. *Energy*
3. *Climate change*

ReCiPe:
1. *Energy*
2. *Climate change*
3. *RE air*

Comparison :
Macbeth (IC) vs Electre III vs Prior

Comparison of the different final scores obtained with the three methods Macbeth, Electre, and Prior (identical scores for each expert are marked in green, and totally divergent scores – 3 different scenarios – are marked in orange).

Note : with the PRIOR method, scores are not individual but « normalized »

Methods / *Experts*	Best scores or ranks			Worse scores or ranks		
	Macbeth CI k-add	Electre III	Prior (ReCiPe)	Macbeth CI k-add	Electre III	Prior (ReCiPe)
F2	EV-GE	EV-FR	EV-FR	Gas. CEV	EV-EU27, Dies. CEV	Gas. CEV
F1	EV-GE	EV-GE	EV-FR	Dies. CEV	EV-EU27	Gas. CEV
E2	EV-GE	Gas. CEV	EV-FR	EV-FR	EV-FR, EV-EU27	Gas. CEV
E1	EV-GE	Gas. CEV	EV-FR	Dies. CEV	EV-EU27	Gas. CEV
D2	EV-FR	EV-FR	EV-FR	Gas. CEV	Dies. CEV	Gas. CEV
D1	EV-FR	EV-FR	EV-FR	Dies. CEV	EV-EU27	Gas. CEV
G2	EV-FR	EV-FR	EV-FR	Dies. CEV	Gas. CEV	Gas. CEV
G1	EV-FR	Dies. CEV	EV-FR	EV-EU27	Gas. CEV	Gas. CEV
B1	EV-FR	EV-GE	EV-FR	Dies. CEV	EV-EU27	Gas. CEV
B2	EV-GE	Dies. CEV	EV-FR	EV-EU27	Gas. CEV	Gas. CEV
A1	EV-FR	EV-FR	EV-FR	Dies. CEV	Gas. CEV	Gas. CEV
C1	-	EV-GE	EV-FR	-	EV-EU27	Gas. CEV

Learnings and conclusion

- The aim of multicriteria analysis is to model the decision-behavior of a decision-maker (or a group of decision-makers) who is (are) facing a complex decision.
- To choose to optimize (ie. to indicate, in all circumstances, the best decision) comes down implicitely to adopt a monocriteria approach, and furthermore to accept the compensation principle.
- The case study clearly shows the high sensibility of the scoring or ranking results with the MCDA method.
- The final solution given by MCDA not only depends on the implemented method but also on decision-maker's preferences.
- Furthermore the choice of a specific method depends on the context : resources, problematic, available data, objective
- The case study and, beyond, the experience indicate that the MACBETH method with Choquet integral 2-additive is the best compromise between required resources (costs) and performance (accuracy of the transciption of decision-maker's preferences).
- More than identifying the best scenario, multicriteria analysis by revealing the decision-maker's preferences helps to build the justification for the choice of one particular LCA scenario, and so can helps to justify the decision-making.

General conclusion

1. An illusion to erase : the truth is unreachable
2. Total compatibility between MCDA and LCA …
3. … nonetheless the costs : accuracy = complexity = implementation costs
4. Single score practices in LCA : a challenge for the LCA community

Perspective

1. **Sensitivity analysis (MCDA) and uncertainties**

2. **The question of generalization within companies**

   a) Panel of decision-maker

   Consensus versus compromise : a unique collegial model of decision-behavior versus fusion of individual decision-behaviors

   b) Product portfolio (MCDA for each product LCA)

   « Top-down » approach versus « bottom-up » approach