

ENVIRONMENTAL EFFECTS IN ECO-EFFICIENCY: HOW TO EVALUATE THEM?

A practical proposal for weighting across environmental impact categories

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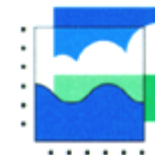
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project commissioned by EC JRC-IES, Ispra



Content

- context of the weighting project
- impact Assessment (IA) and weighting in LCA
- selection of weighting methods
- results:
contribution of emissions and extractions to the impact score
- combined weighting method
- results:
impacts of material consumption, EU15 1990-2000
- conclusion



context of the weighting project

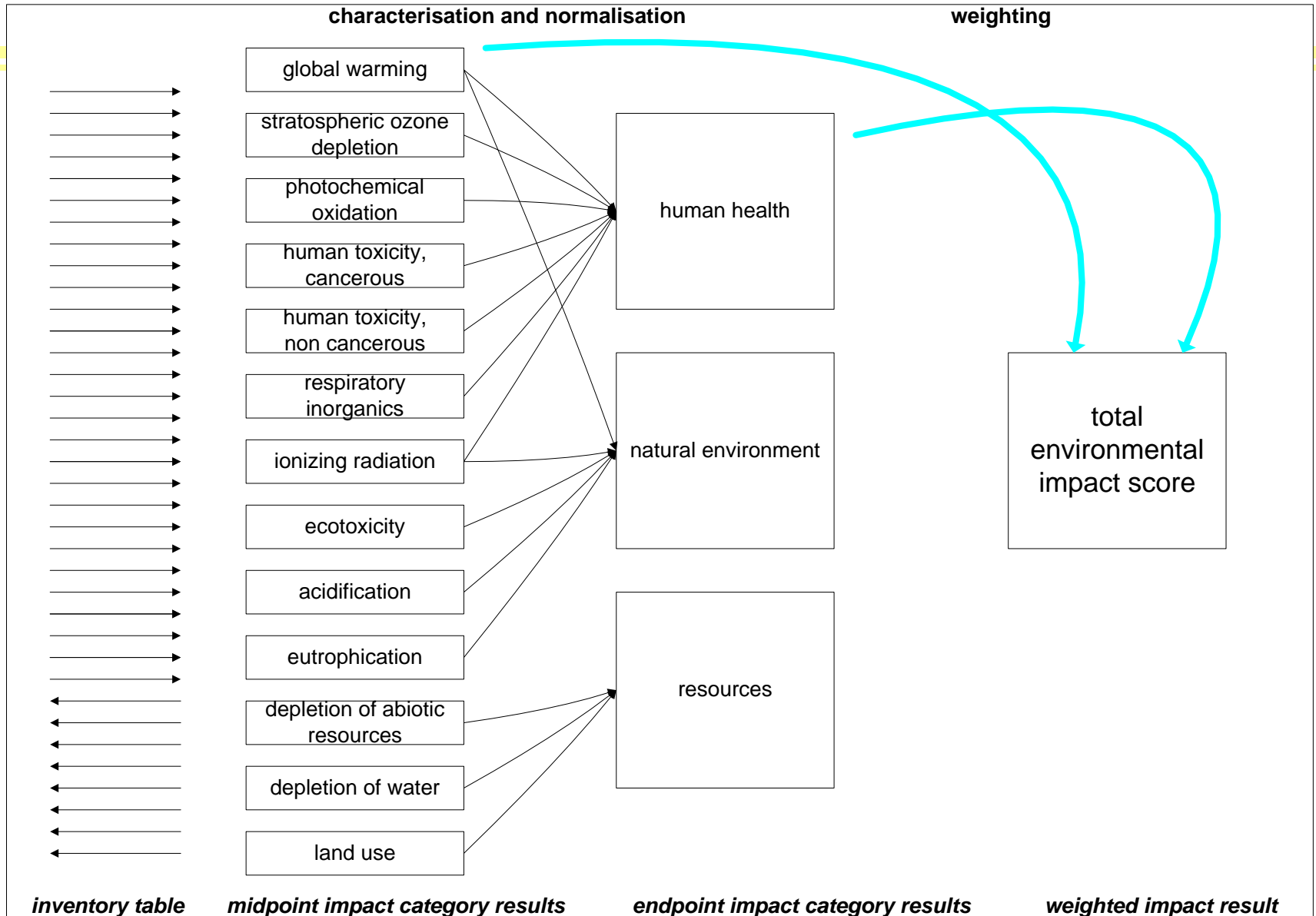
- policy context: EU thematic Strategy on the sustainable use of natural resources,
- possible use: decoupling indicator, coordinated by EUROSTAT
- commissioned by: EU JRC-IES (European Commission, Joint Research Centre, Institute for Environment and Sustainability)
- scientific context:
 - weighting across environmental effects is step after modelling of environmental effects (characterisation)
 - characterisation models from ILCD¹ recommended environmental impact assessment (Hauschild *et al.*, 2008)
<http://lct.jrc.ec.europa.eu/assessment/publications>

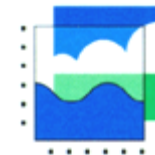
1. International Reference Life Cycle Data System



impact assessment in LCA

some definitions





selection of weighting methods

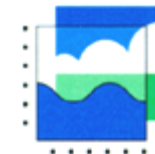
- review of approximately 15 operational weighting methods
- main selection criteria:
 - compatible with ILCD recommended IA
 - weighting methods based on direct statements (panel, WtP)
- extra: integrated modeling and economic valuation

- midpoint methods

- BEES stakeholder panel	(US)	(panel)
- BEES EPA science advisory board	(US)	(panel)
- NOGEPA	(EU)	(panel)
- endpoint methods

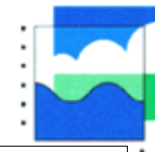
- Ecoindicator99	(EU)	(panel)
- LIME	(Japan)	(panel)
- ReCiPe damage cost	(EU)	(WtP)
- integrated methods (extra)

- NEEDS+Weitzman	(EU)	(WtP)
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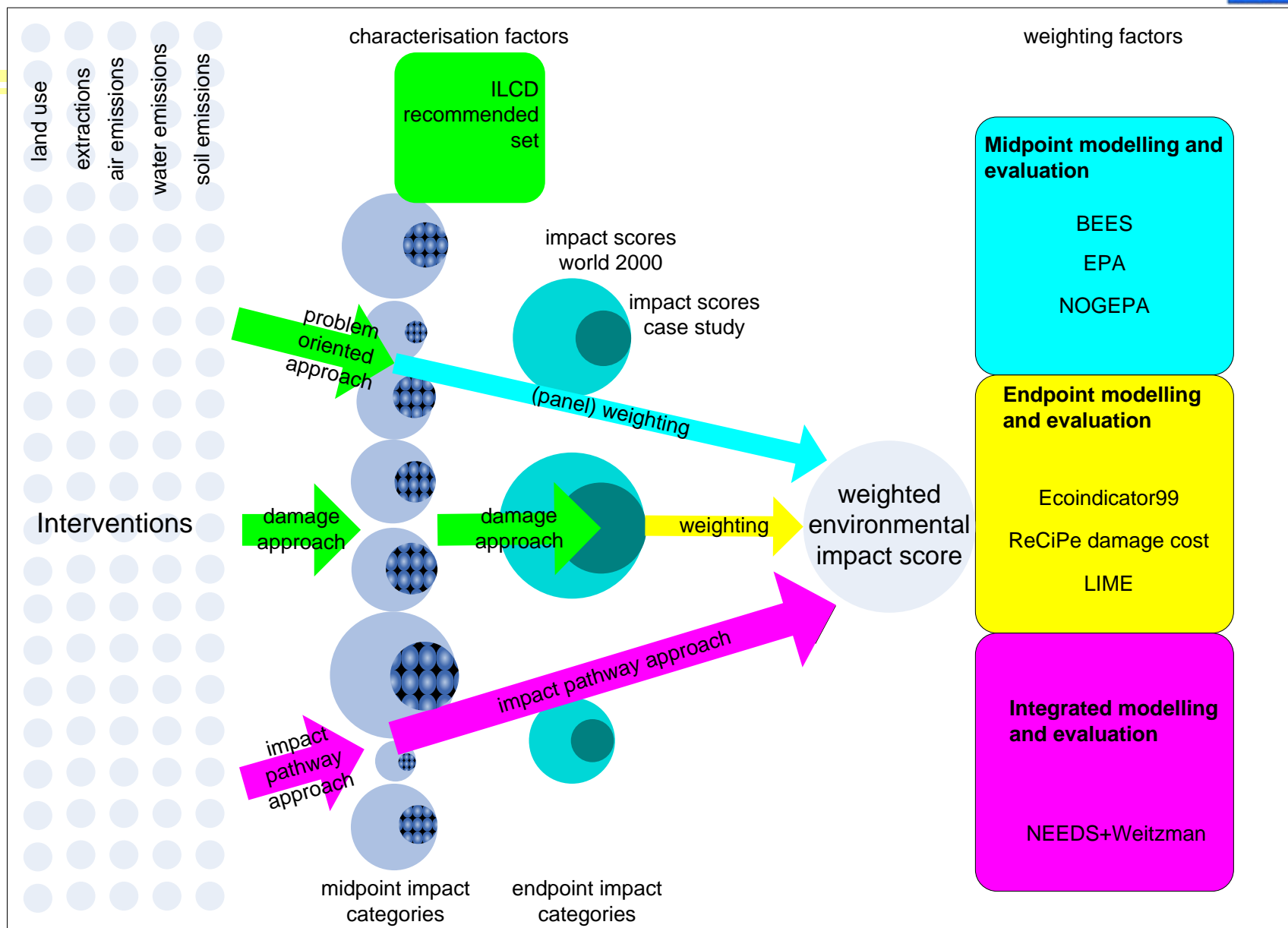


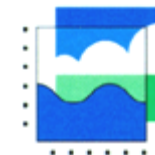
weighting factors of selected weighting methods

Impact category on midpoint level	weighting set						
	EPA Science Advisory Board	BEES Stakeholder Panel	NOGEPa with additional factors				
	%	%	%	%	%	\$/unit damage	euro/kg emission
Climate change	16	29	25				0.006 (CO2)
Ozone depletion	5	2	4				
Human health cancerous	7	8	5				3.7E7 (dioxin)
Human health non-cancerous	4	5	3				278 (lead)
Particulate matter/respiratory inorganics	6	9	5				6.07 (SO2)
Ionising radiation, human health	6	2	3				0.0014 (C14)
Photochemical ozone formation	6	4	6	33	30	60000	
climate change	N/A	N/A	N/A				
Acidification	5	3	5				
Eutrophication	5	6	10				
Fresh water ecotoxicity	11	7	15				
Ionising radiation, ecosystems	6	2	3	52	40	1.75E11	
abiotic resource depletion	5	10	6				0.00103 (oil)
Water intake	3	8	4				
Land use	16	6	8	14	30	1	



overall set up of characterisation and weighting

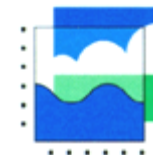




Contribution of interventions to total impact score (%)

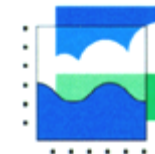
Result inventory table EU27 (Wegener Sleeswijk et al., 2008)

substance	compartment	midpoint modeling (ILCD) and weighting			endpoint modeling (ILCD) and weighting			Integrated modeling and valuation NEEDS+Weitzman
		BEES	EPA	NOGEPa	ecoindicator99	LIME	ReCiPe damage	
carbon dioxide	air	22	11	19	9	9	16	37
carbon-14	air	5	16	9	16	16	10	
mercury	air	12	9	7	9	9		
zinc	air	9	7	6	8	8		4
hydrogen-3	air	3	10	6	13	15	56	
benzene	air	8	6	5	5	5		
nitrogen dioxide	air	5	5	7	3	3		13
sulfur dioxide	air	3	3	3	3	3		9
methane	air	3	2	3	1	1	2	9
lead	air	3	2	2	3	2		
chlorpyrifos	agricultural soil	1	2	3	1	1		
nitrous oxide	air	2	1	2				21
particles (PM10)	air	2	1	1	1	1		1
atrazine	agricultural soil	1	2	2	1	1		
iodine-131	air	1	2	1	3	4	13	
chlorothalonil	agricultural soil	1	1	2	1	1		
non-methane volatile organic compounds	air	1	1	2	1	1		2
phosphate	water	1	1	2	4	4		
formaldehyde	air	2	1	1	1	1		
cyanazine	agricultural soil	1	1	1				
total		85	86	84	84	86	97	94



three basic approaches combined

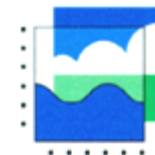
- all methods have their strengths and weaknesses, there is not one right, generally accepted, method
- midpoint method: robust modelling, but interpretation and judgement of midpoint results in the head of 'experts'
- endpoint method: based on midpoint and add highly uncertain further effect modelling, but with less endpoints to weigh across
- integrated modelling: strong points in modelling human toxicity and climate change, but weak for other impacts. Valuation step is best specified but tried methods are not undisputed



the combined weighting method exemplary setting in IA spreadsheet

type of weighting approach	operational weighting sets	meta weighting set
midpoint modelling and evaluation	BEES	25
	EPA	25
	NOGEPa	25
endpoint modelling and evaluation	Ecoindicator99	2
	LIME	2
	ReCiPe damage value	1
integrated modelling and evaluation	NEEDS	20
		100

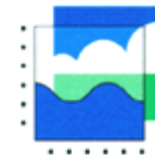
Table... Proposed selection of weighting sets in the meta weighting tool



an example

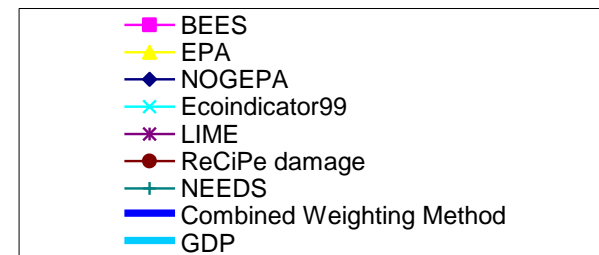
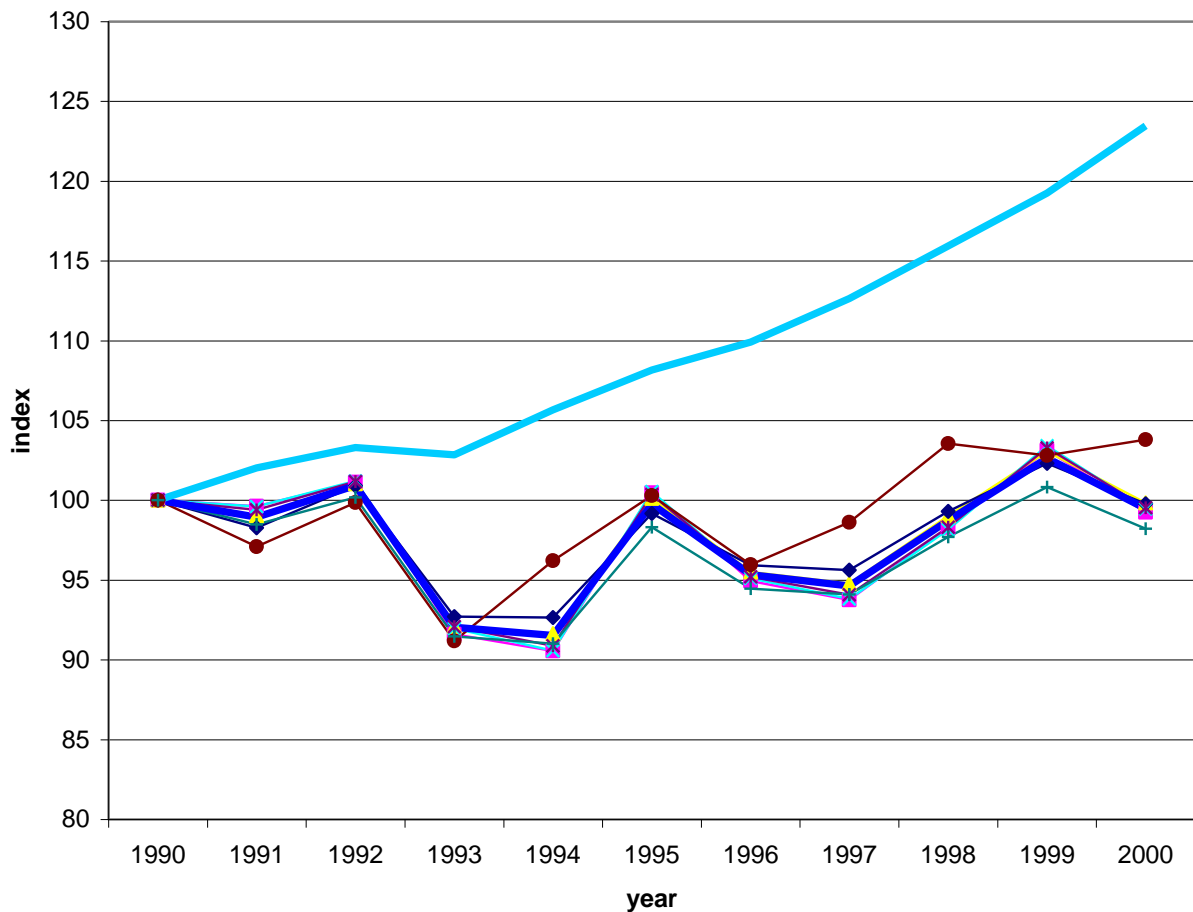
EMC for EU15 in 1990-2000

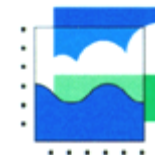
- environmentally weighed material consumption indicator (EMC)
- decoupling indicator to support the EU Thematic Strategy on Natural Resources (Voet et al., 2009; Voet et al., 2005).
- constructed impacts of EU15, using:
 1. apparent consumption of materials (EUROSTAT, FAO)
 2. impacts per kilogram material, based on
 - process data of LCA databases (Ecoinvent2.0; LCAfood, 2008)
 - draft ILCD characterization factors (Hauschild et al., 2008)
 3. Weighting methods; BEES, EPA (Lippiatt, 2007), NOGEPa (Huppes *et al.*, 2007), Ecoindicator99 (Goedkoop & Spriensma, 1999), LIME (Itsubo *et al.*, 2004), ReCiPe damage (Heijungs, 2008) and NEEDS (Preiss & Klotz, 2008)



Result

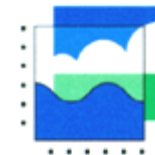
GDP and weighted impacts (EMC) for EU15





Conclusions

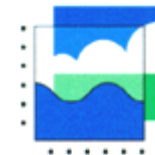
- there is not one right, generally accepted, weighting method
- a combined weighting tool with exemplary setting is proposed
- a start has been made to develop an ILCD recommended impact assessment method, but all results should be considered preliminary
 - missing impact categories: land use, water depletion and ecotoxicity (NEEDS (not ILCD))
 - inconsistent technically: midpoint to endpoint modelling seems not to be completely elaborated
 - inconsistencies between characterisation models used for impact categories: e.g. differences in time scale and geographical scale



END

thank you

for your attention



references

- Huppes, Gjalt and Laurant van Oers, 2009. **Technical review of existing weighting approaches in LCIA.** European Commission, Joint Research Centre, Institute for Environment and Sustainability, Ispra, Italy.
- Huppes, Gjalt and Laurant van Oers, 2010. **Recommended weighting approach for measuring the EU-27 overall environmental impact.** European Commission, Joint Research Centre, Institute for Environment and Sustainability, Ispra, Italy.