SCORELCA

Study N° 2013-04

Summary

ENVIRONMENTAL IMPACT INDICATORS IN LCA:
STATE OF THE ART, FEEDBACK AND RECOMMENDATIONS

Guide for LCA practitioners - final

November 2014

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SCORE LCA is an association that has been created to financially support collaborative research on LCA and related topics. It aims to promote and organize cooperation between companies, institutional and scientists in order to support the evolution of LCA methods and its practical implementation at European and international level.

- ✓ This work has been supported by ADEME (Agence de l'Environnement et de la Maîtrise de l'Energie) www.ademe.fr

- ✓ The views and recommendations expressed in this publication are those of the authors and do not necessarily reflect, unless otherwise stated, the views of all members of SCORE LCA.

- ✓ The information and conclusions presented in this document were established on the basis of scientific and technical data and regulatory and normative framework in force at the date of the publication of documents.

I. Introduction

The evaluation of the life cycle impact only addresses the environmental problems that are identified in the objectives and scope of the study. As a result, it is not a complete evaluation of all the existing environmental issues. The choice of impact categories is thus an important step during the making of an LCA. The practitioner is confronted with the duality of being both complete and efficient during his evaluation.

Given the diversity of characterization models that can be associated with a same impact category, the practitioner also faces difficulties in the selection of these models. Various criteria can then guide his choice in his study frame: the scientific robustness of the methods, the adequacy with the accessible inventory data, the relevance to local environmental issues, etc. Moreover, guidance documents emerge in order to help practitioners and augment the comparability between studies. Nevertheless, the task remains complex.

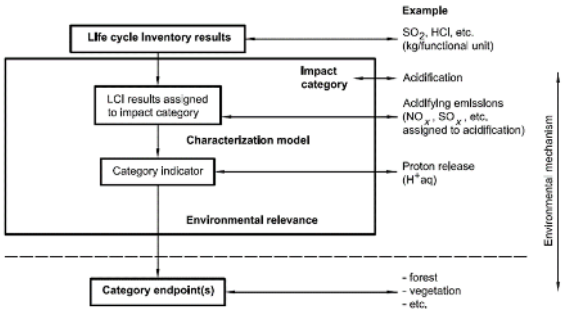
This study has as goal to guide the practitioner in his choice and interpretation of impact category indicators. In order to elaborate recommendations, a state of the art of the categories and methods used in LCA has been drawn and the reference documents have been analyzed. The state of the practice was further analyzed based on a survey of more than 100 actors.

This review summarizes the contributions of these different approaches and presents the recommendations, attention points and perspectives to which the study has led. The final paragraph picks up a flowchart helping the practitioner in his decision making process.

II. Terminology

Every impact category possesses its own environmental mechanism. Characterization models reflect the environmental mechanism describing the relationship between the LCI results, the category indicators, and, in some cases, the final impacts (endpoints) for each category. Figure 1 and Table 1 illustrate the concepts of impact category or final impact indicator based on an environmental mechanism (the categories “Air acidification” and “Climate change” are used as an example).

Figure 1 : Illustration of the terminology for the example of the air acidification and climate change impact category (Source ISO 14044:2006)



Term	Example
Impact category	Climate change
LCI results	Greenhouse gases
Characterization model	IPCC [a] model
Category indicator	Infrared radiative forcing (W/m^2)
Characterization factor	Global warming potential for each greenhouse gas (kg CO_2-equivalents/kg gas)
Indicator result	kg of CO_2-equivalents
Category endpoints	Coral reefs, forest, crops
Environmental reference	Degree of linkage between category indicator and category endpoint
NOTE Further examples are provided in ISO/TR 14047 [1].	
[a] Intergovernmental Panel on Climate Change.	

According to the richness of scientific publications and international consensus, various characterization models can exist for a unique impact category.

III. Analysis of impact indicators

This chapter allows LCA practitioners to understand the advantages and limits of each method.

The scope of the analysis consists in evaluating the existing methods for 12 different environmental impact categories through 4 mono-indicator methods and 8 multi-indicator methods. This includes the most recent developments concerning the LC-IMPACT method. Most of these works are based on:

- « Recommendations for life cycle impact assessment (LCIA) in the European context » published in « ILCD Handbook (European Commission, 2011) » ;
- « Recommended assessment framework, characterization models and factors for environmental impacts and resource use (Dong et al, 2013) » published in the frame of « FP7 funded project PROSUITE »
- A vast consultation of stakeholders that has taken place within the framework of this project

The existing characterization methods and models have been evaluated according to the following criteria:

- Environmental relevance – relevance of the covered mechanisms ;
- Completeness of the scope – number of covered elementary flows;
- Recognition of the scientific robustness – Robustness and reliability of the models as well as reproducibility; the main limitations of the methods with respect to each other will be identified. The term defines in this case the recognition of these methods by LCA practitioners. But other impact evaluation models/methods (other than LCA-based) may have a better scientific robustness in the absolute to describe impacts.
- Documentation, transparency, reproducibility – documentation publication, accessibility, possibility for third parties to reproduce the calculations.
- Applicability : Ease of application (ex : methods that have (or haven't) been implemented in the software) ;
- Degree of acceptance by stakeholders and ease of communication in the context of business or policies

The proposed recommendations following this analysis are of two kinds:

- **General recommandations and perspectives;**

Recommendation 1 : The LCA practitioner has to be very wary when using a set of methods coming from other sources/authors.

The LCA practitioners have to be very cautious when using a set of methods that is compiled from a number of other methods.

In general, the method developers have put many efforts in the creation of a coherent impact indicator set that does not contain any overlaps or gaps and have taken care of reaching the highest coherence level concerning, for instance, the methodological choices.

Recommendation 2 : The LCA practitioner has to be very cautious when using a set of methods coming from a same source or author

At the same time, the choice of methods per impact indicators, as did ILCD, shows that no method designer can be the best for all environmental impact indicators. This implies therefore that when using a single method for all indicators, it is not the most current / robust for the entire set of impacts.

Recommendation 3 : If the time available for the achievement of the study allows it, it is better to carry out the production and analysis of the results with a double set of methods: (i) set of unique methods, (ii) set of different methods

The interpretation of the results in the light of two sets of methods allows to draw conclusions that converge on basis of the analysis of the results from two points of view and to conclude with more precaution on the diverging elements.

The conclusions that can be drawn from this combined analysis are:

- The identification of the most contributing steps of the life cycle;
- The identification of the most contributing processes ;
- The identification of the most contributing elementary flows.

This allows to target the possibilities for ecodesign with more reliability than when there is use of only one set of methods.

Perspectives 1 : The JRC ISPRA is working on new recommendations for certain environmental impact indicators for the end of 2015

The JRC ISPRA, aware of the current limitations of the formulated recommendations in the ILCD document, is currently working on the elaboration of new recommendations for 3 to 5 impact indicators. These recommendations will be based on the new developments that have taken place during these 5 passed years and will concern especially the depletion of water and depletion of fossil and mineral resources.

Perspective 2 : A big workshop will be organized on the initiative of the SETAC in order to determine a general orientation frame for the evaluation of environmental impacts.

For the future, we hope that the global alignment process currently undertaken by the UNEP initiative LC SETAC will bring more context and clarity on the subject.

- **Recommendations on the choice of characterization methods coming from the most up to date scientific publications : ILCD and PROSUITE**
  - Table 2 lists the recommended methods for intermediate effects for different environmental impact indicators.

Table 1: Recommended methods for intermediate effects

Category	ILCD Handbook midpoint	PROSUITE midpoint
Climate change	IPCC GWP100	IPCC GWP100
Ozone depletion	WMO100	WMO100
Human toxicity	USEtox	USEtox
Particulate matter	Humbert et al 2009	Humbert et al 2011
Ionising radiation	Frischknecht et al. (2000)	Frischknecht et al. (2000)
Photochemical ozone formation	ReCiPe	ReCiPe
Acidification	Accumulated Exceedance	Accumulated Exceedance
Eutrophication (terrestrial)	Accumulated Exceedance	Accumulated Exceedance
Eutrophication (aquatic)	ReCiPe	ReCiPe
Ecotoxicity	USEtox	USEtox
Land occupation/transformation	Mila i canals et al. 2007	Mila i canals et al. 2007
Water scarcity	Ecological scarcity	Pfister et al 2009
Abiotic resource scarcity	CML (reserve base)	CML (not specified)

  - Table 3 lists the recommended methods for final effects for different environmental impact indicators.

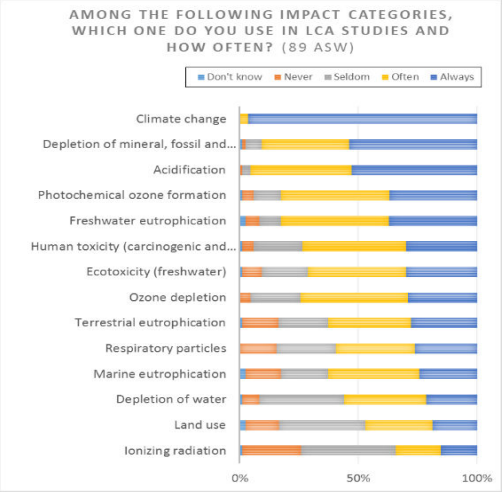
Table 2 : Recommended methods for final effects

Category	ILCD Handbook endpoint	PROSUITE Endpoint
Climate change (not freshwater)	None	ReCiPe
Climate change (freshwater)	None	LC-IMPACT
Ozone depletion	ReCiPe interim	ReCiPe
Human toxicity	USEtox/Huijbregts	USEtox/Huijbregts
Particulate matter	ReCiPe adapted	LC-IMPACT
Ionising radiation	None	Frischknecht et al. (2000)
Photochemical ozone formation	ReCiPe	LC-IMPACT
Acidification	ReCiPe interim	LC-IMPACT
Eutrophication (aquatic)	ReCiPe interim	LC-IMPACT
Ecotoxicity (freshwater)	None	USEtox/ReCiPe
Land occupation/transformation	ReCiPe interim	LC-IMPACT
Water scarcity	None	Pfister et al 2009
Abiotic resource scarcity	ReCiPe interim	LC-IMPACT

IV. The results of the survey of practitioners

A state of the LCA practice has been performed, based on an anonymous web survey. The panel of respondents is of 110 persons, broken down in three different profiles: the academics/researchers; the consultants; and the LCA practitioners within companies. Various themes have been addressed.

- **Use of impact categories and selection phase :**
  - 90 % of the respondents allow importance to this selection step. In contrast about 10% do not linger on the step of selecting because they are guided by a referential.
  - About 45% of 110 surveyed persons have tried to propose a minimum number of impact categories that have to be studied. This minimum threshold is between 3 and 5 impact categories. They frequently justified this by the desire to have a consistent relationship between the ease of reading and understanding the LCA and the multi-criteria approach (proper to LCA) that must be preserved.
  - The 5 impact categories that are always or frequently studied by more than 80% of the practitioners are (in decreasing order):
    - Climate change
    - Mineral and/or fossil resource depletion
    - Air acidification
    - (freshwater) eutrophication
    - The formation of photochemical ozone



  - Conversely, 3 categories that are never or little brought up by more than 50 % of the practitioners are (in decreasing order):
    - Ionizing radiation
    - Land use
    - Water resource depletion
  - The 2 criteria illuminating the stage of selection of impact categories largely highlighted by the survey are:
    - The objectives of the study;
    - Specific environmental issues of the studied system.
- **The selection of impact characterization methods and their indicators:**
  - The « global » CML and ReCiPe methods are the most commonly used, whereas Impact 2002 + is included more often. The practitioners dig mainly in these two global methods depending on the impact categories that have to be evaluated ;
  - Furthermore, this analysis provides us some strict tendencies :
    - Concerning the greenhouse effect, the IPCC 2007 methods is almost the only one used (it is used in the "global" CML and ReCiPe methods…)
    - Concerning terrestrial eutrophication and resource depletion, only the CML method is commonly used;

- Concerning human toxicity and ecotoxicity, USEtox is the acknowledged method;
- For Land use, the most commonly used method is the ReCiPe method;
- There is a remarkable equality (but based on a small population) for the methods concerning water use: Pfister and Frishknecht

	Respondents	Choice 1	Choice 2	Choice 3	Choice 4	Choice 5
Climate change	82	IPCC 2007				
		97.6%				
Ozone depletion	68	ReCiPe	CML - IA	EDIP		
		60%	53%	6%		
Air acidification	66	CML-IA	ReCiPe	IMPACT 2002+	EDIP	
		53%	50%	21%	6%	
Freshwater eutrophication	67	ReCiPe	CML-IA	USEtox	IMPACT 2002+	EDIP
		54%	34%	24%	18%	5%
Respiratory particles	59	ReCiPe	CML-IA	IMPACT 2002+	Riskpoll	
		59%	37%	31%	9%	
Marine eutrophication	58	ReCiPe	CML-IA	USEtox	IMPACT 2002+	EDIP
		50%	38%	21%	21%	5%
Terrestrial eutrophication	52	CML-IA	EDIP			
		92%	12%			
Depletion resources	36	CML-IA	ReCiPe	IMPACT 2002+	EDIP	
		81%	33%	25%	6%	
Ecotoxicity (freshwater)	36	USEtox	ReCiPe	CML-IA	IMPACT 2002+	EDIP
		56%	33%	33%	19%	0%
Human toxicity	36	USEtox	CML-IA	ReCiPe	IMPACT 2002+	EDIP
		56%	39%	36%	22%	0%
Photochemical ozone formation	34	ReCiPe	CML-IA	IMPACT 2002+	EDIP	
		59%	47%	18%	0%	
Ionizing radiation	25	ReCiPe	CML-IA	IMPACT 2002+		
		60%	40%	16%		
Land use	23	ReCiPe	IMPACT 2002+	Soil organic matter		
		83%	22%	13%		
Depletion of water	13	Pfister	Frischknecht			
		54%	54%			

- The 5 criteria particularly[1] influencing the selection of characterization methods are (in decreasing order):
  - The scientific robustness of the models;
  - The reference text recommendations (e.g. ILCD, PCR…)
  - Age of the method
  - The availability of the method in the LCA software

  The consistency between the completeness of the conducted inventory and the characterization method

  Conversely; the availability of regionalized factors, as well as the descaling factors, are but secondary criteria and little determining in the choice of characterization methods.

[1] Gathering a minimum of 75% of « large influence » or « influence » notice

- The survey also allowed to identify some practices of **method and characterization model modification:**
  - 47 practitioners claim to process/modify characterization methods or LCI data in their LCA software. The reasons given are:
    - Name deviations or completeness between lists of inventory flows and characterization factors lists. For example, practitioners add one (of the) characterization factor(s) to apprehend the biogenic carbon flux;
    - Modify characterization factors in order to make them specific to the studied area (regionalization).
  - 50 practitioners have in such manner updated or implemented a characterization method with varying motivations:
    - Correct implementation errors or deficiencies (especially for USEtox methods);
    - Separate the long-term emissions and short-term emissions;
    - Update characterization factors as a result of new publications or proposals of experts (eg IPCC Climate Change);
    - Add methods to new impact categories or aggregate flows: odor indicator, waste indicator, ...
    - The following table provides all the flow indicators that the practitioners can propose.

Energy consumption or cumulative energy demand	Water inventory (input/output) or more complex water footprint indicators
Smelling	costs,
Waste generation	Hazardous waste generation
stock creation of resources	Sometimes we add worker health.
Pfister for water	Radioactive waste (if ionizing radiations not included in the set)
Biotic Resource Use	Nitrogen flow (agricultural product)

- **Use and selection of endpoint impact categories**
  - The endpoint impact categories are used frequently. About 40% of practitioners claim they use them ‘always’ to ‘frequently’ and only 20% claim never to use them.
  - When endpoint impact categories are used, a large majority of practitioners (75% say frequently or always) also use midpoint impact categories.
  - The most common characterization methods are (in decreasing order of use):
    - ReCiPe;
    - IMPACT 2002+;
    - EcoIndicator 99.
    - The other methods (LC Impact, EPS 2000 LIME, Ecological scarcity 2006) are used only occasionally.

V. The requirements and recommendations of guidance documents and ISO standards

- **The purpose of impact categories and their indicators is to condense and to explain LCI results**

  The impact categories and indicators allow a better grasp and understanding of the results and consequences that a life-cycle inventory of a product can have on the environment. The impact categories and indicators condense and explain the LCI results.

- **The selection of intermediate impact categories and endpoints, of their indicators and associated characterization methods is a must to achieve.** It must be coordinated with the other steps of the LCA, as part of the iterative process.

Once an LCA uses impact categories (optional, an LCA can simply propose LCI), the following elements are necessarily defined within the meaning of ISO 14044: 2006:

  - The description of the selection of impact categories, indicators, and sets of associated characterization models;
  - But also LCI data that impact categories will analyze, in other words the elementary flows associated with the characterization methods;
  - The identification of the associated final impact.

- **Several other mandatory elements exist:**
  - There must be a consistency with the objective of the LCA study;
  - The selection should also reflect a set of environmental issues that are specific to the studied system and to the scope of the study;
  - The selection must be justified and documented in the LCA report and specific, correct, and descriptive names should be used.

- Following the previous recommendations, which are mandatory as defined in the ISO 14040 series of standards, **other recommendations are proposed with more flexibility** (within the meaning of the English word '*should*' as opposed to the word `*shall*')
  - Use indicators, impact categories and characterization models accepted and shared internationally, by an organization recognized as competent. We can mention: UNEP, SETAC, JRC;
  - The choice of values or arbitrary values and assumptions must be minimized during the selection of the impact categories, their indicators and characterization models;
  - The selection should identify double counting, for example if the molecules have successive potential impact, such as heavy metals. Indeed they have impacts on the ecotoxicity, and when they enter the food chain, also have a role on human health;
  - The indicators that are selected are relevant to environmental issues. For example, one can frequently wonder about the impact category dealing with the

depletion of the ozone layer when the system studied is not particularly contributor (transmitter of CFCs..). Indeed, this environmental problematic tends to be resolved with the actions already taken in recent years (final resolution in the long term, 2030).

- **Simplifications, assumptions and / or value choices made in the characterization models strongly influence the usefulness of an indicator** (especially for decision making that the LCA allows).
- The characterization models are often a **compromise between the simplification and the accuracy of the complexity of environmental mechanisms.** Thus the recommendations and qualifications offered by JRC 2011[2] are very helpful to sort the really useful impact category indicators for decision making with respect to simplifications, assumptions and value choices.
- **Characterization models allowing the spatial and temporal differentiation of characterization factors and the regionalization of the LCI are to prioritize.**
- **Pragmatic help regarding selection**

ISO 14040-44 norms offer only generic rules for LCA. It is therefore preferable that the assessments and summaries allowing to inform the practitioner in the selection be made more widely. This is for example the lens:

  - Of the JRC's work in 2011 through the publication of 'Recommendations for Life Cycle Impact Assessment in the European context' - JRC: 2011;
  - Of the rules by product category (PCR : Product Categories Rules) such as: NF EN 15804: 2012 or the BP X 30-323-0: June 2011.

- **Limits relevant to recall during an LCA assessment:**
  - LCA only addresses environmental problems identified in the objectives and scope of the study. That is why **LCA is not a comprehensive assessment of all the environmental problems of the studied product system;**
  - Lack of spatial and temporal dimensions in the life cycle inventory results (very common) introduces uncertainty in the LCA results. The uncertainty varies according to the spatial and temporal characteristics of each impact category.
- During the classification phase of the elementary streams contributing to an impact category indicator (or during the interpretation of LCA results and this classification), **the LCA practitioner shall distinguish, for the flows of the contributing ICV, the parallel environmental mechanisms from the serial mechanisms.**

  For example, SO_2 flow is distributed in parallel for indicators dealing with human health and acidification (with no interaction between the two environmental mechanisms, which are non-cumulative). While NOx can be classified as contributing both to the formation of ground-level ozone and acidification via an environmental mechanism in series.

[2] Recommendations for Life Cycle Impact Assessment in the European context –JRC: 2011

VI. The influence of the choice of characterization models

Several publications aim to apply different methods of assessing impacts within the same study. The goal is to compare the results and assess the influence of the choice of characterization methods on the findings of the study.

- The publication of Weidema (2014)[3] highlights the risks associated with integrating new methods:
  - Some critical assumptions justify most of the observed differences, such as the non-substitutability of resources in ReCiPe 2008. These assumptions should be validated in particular;
  - Residual errors in the methods may remain.
- The article Owsianiak (2014)[4] attempts to identify the source of the differences among the three possible causes:
  - Differences in characterization models;
  - Differences in the coverage of substances;
  - The implementation errors in the software.

  Depending on the compared methods, the three contribution types have been met. It shows the following recommendations:
  - For problematic categories, important differences between methods were identified at the level of the most contributing flows. If the same differences are observed in many case studies on other goods and services, the recommended categories by the ILCD are to be used with caution;
  - Attention should be paid to how the factors were implemented in the used software;
- In its paper Maki Consulting (2014)[5], states that different results may be obtained from the same inventory and the same characterization method but in different software. To discuss concretely that point, the comparison made by OpenLCA consists in a representative support[6]. This is the comparison of ACVI results for 6 processes from the ecoinvent v2.2 database. The results obtained in OpenLCA and SimaPro for the methods of the "ILCD 2011 midpoint" set are compared. Here are the impact categories for which differences are observed:
  - Climate change: only methods including capture of CO_2 in the air differ.

[3] Weidema. Comparing Three Life Cycle Impact Assessment Methods from an Endpoint Perspective, Journal of Industrial Ecology, published online: (2014)
Renou et al. Influence of impact assessment methods in wastewater treatment LCA. J Clean Prod 16:1098–1105 (2008)

[4] Owsianiak et al. IMPACT 2002+, ReCiPe 2008 and ILCD's recommended practice for characterization modelling in life cycle impact assessment: a case study-based comparison. Int J Life Cycle Assess 19:1007–1021 (2014)

[5] Maki Consulting, National LCA Databases – Status and ways towards interoperability (2014)

[6] Greendelta, Quality Assurance of openLCA LCIA methods - Comparison with SimaPro 8, February 2014. http://www.openlca.org/documents/14826/130f0de0-c466-468a-82fa-43fea91e04ad . Dernier accès : 29/10/2014.

- Freshwater ecotoxicity et Human toxicity – non-carcinogenics: for these two indicators, it is the mapping of flows related to arsenic ions that cause problems;
- Ionizing radiation - ecosystems, Land use and Resource depletion - water: In all three cases, the differences are rooted in the extension of characterization factors for certain elementary flows to additional sub-compartments;
- Resource depletion - mineral, fossils and renewables: several differences exist. The main one, according to the study, is related to the modification of several inventories by SimaPro, including the replacement of elementary flows which are mixtures of metals by pure metals. However, in ILCD factors, there are no factors for mixtures of metals, only for pure metals.

VII. Conclusions, perspectives and general recommendations

This chapter brings together the key elements to emphasize when an LCA practitioner asks himself which impact category, of indicator and associated characterization method he has to select. It includes general conclusions from the analysis of the theory and practice, perspectives showing work in progress or to be undertaken in order to assist practitioners and finally recommendations for practitioners to apply in their LCA work.

Conclusion 1: The selection of impact categories should be related to the purpose and scope of the study

The number and type of impact categories depends on the purpose of the study, the target audience, the type of product and the available data. In order to guide the practitioner in the selection task, reference materials have been established. They relate specifically to certain types of studies, including environmental labeling programs and type III environmental statements. The main criteria used to identify the relevant impact categories are:

- The existence of robust and reliable methods;
- The availability of primary and secondary data in connection with the intended impacts;
- The importance of the issue (especially evaluated to support a normalization) for the type of product involved;
- Redundancy and consistency of indicators

Conclusion 2: Selection of characterization methods can influence the results of a study

The nature of the characterization models and completeness can influence the results in terms of most contributing elementary streams to an impact category. As part of a comparative LCA, the findings of the comparison may vary depending on the chosen method, for some indicators. The differences are even more important when the uncertainties about the factors are high and inventory data are difficult to collect.

Conclusion 3: Elementary flows covered by the inventory may differ from those included in the characterization method

The list of elementary flows involved in an impact indicator may cover more or less flows than the inventory data. There is therefore a risk of unsuitability between the choice of a method and the available data. Furthermore, the nomenclatures of the different sources may differ. This results in integration difficulties into the databases and software, and even differences in results between different implementations.

Similarly, inventories serving as descaling data come from statistical sources, which are different from present inventories in the databases for elementary processes. This also results in a bias on the descaling factors.

Conclusion 4: The recommendation of characterization methods in the repositories contributes to the comparability of studies

In programs where studies conducted by different people have to be directly compared, the consistency of selection methods and characterization factors ensures the comparability of results.

The extensive publication of characterization factors in the reference documents (such as in the standard 15804: 2012 + A1: 2013) provides stability to factors at least until the next revision of the document. These documents are, at the present stage of development, frequently updated.

Perspective 1: The use of methods taking into account a spatial differentiation is expected to increase

At present, taking into account geographical aspects is more apparent by the choice of methods specifically developed in the context of a given geographic area (e.g. TRACI for North America) than by the use of methods providing a spatial differentiation, at the location of the elementary flows or processes. However, this is very likely to change considerably in the coming years with the development of regionalized methods (World Impact + and LC-Impact) and their gradual implementation in databases and software.

Contrariwise, the association of uncertainty to characterization factors and the temporal component of elementary flows are more distant perspective in time.

Perspective 2: Work continues in order to improve recommendations

Following the test period of the PEF, the JRC plans to revise its recommendations in terms of LCIA, particularly in connection with the water depletion and resource depletion (revision expected for end 2015). In addition, the global alignment process currently undertaken by UNEP - SETAC should culminate in 2016 with the publication of both guidelines for LCIA and characterization factors.

Perspective 3: Different database providers collaborate to improve the correspondence tools between nomenclatures

The differences in nomenclatures between databases, as well as between method developers pose great difficulties to stakeholders. To reduce these problems and to facilitate interaction between the different data sources, conversion tools continue to develop, particularly in the JRC initiative.

Final Recommendation 1: The LCA practitioner must be transparent and justify the selection of impact categories and characterization methods

If the study is consistent with a specific reference document which defines the number and nature of the impact categories to be included, the practitioner shall make explicit reference to it.

Otherwise, according to ISO 14040-44 norms, the practitioner should consider a priori all impact categories and justify the possible exclusion of impact categories depending on the

purpose and scope of the study. He must reference in a clear and precise manner the used methods.

Regarding the number of impact categories to study, a distinction can be made depending on the target audience. For communication to the end consumer, the number of presented indicators may be limited, including at least the 3 most relevant categories.

Final Recommendation 2: The LCA practitioner must be careful when using a set of indicators from different methods

In general, the developers of methods have put a lot of effort into creating a coherent set of impact indicators minimizing overlaps or gaps. They made sure to achieve a high level of consistency.

By using impact indicators from a single method, the practitioner avoids double counting and inconsistencies. This recommendation applies particularly to cases where endpoint indicators are assessed or if normalization is applied.

If they use a set of midpoint indicators compiled from several different methods, LCA practitioners should be very cautious in interpreting the results.

Final Recommendation 3: The practitioner must be sure to use different methods for a same indicator where the issue of decision making justifies it

In the absence of recommendations of specific methods and / or when the decision is sensitive, the practitioner can compare results obtained through multiple methods. In practice, it may proceed with the production and analysis results with: (i) a homogeneous set of methods, (ii) a set of different methods (e.g., the ILCD selection).

He can thus test the robustness of the findings and better highlight areas of uncertainty or limits (including completeness of inventories and methods).

Furthermore, if no consensus exists on the most accurate method and indicator for the impact category, using multiple characterization methods often allows to identify a stage of the life cycle, or a major unit process and to target ecodesign tracks on this step. Although the results of this approach are limited, interesting elements can still be drawn.

Final Recommendation 4: The practitioner must keep a critical view on the completeness of inventories and the integration of characterization methods

A critical eye must be kept on the coherence between the available inventory data and impact assessment methods, both in terms of completeness and in terms of flow classification. In particular, the practitioner must identify the LCI data which are not involved in any impact indicator.

When posting a characterization method and accepting its relevance, it takes some time to implement it in software and databases. This process can be long and require feedback of practice (as demonstrated by the integration of ILCD characterization factors by

different actors). One must be careful when using newly implemented methods. Potential errors and high frequency of updating the tool versions are to anticipate.

Final Recommendation 5: data storage as ICV is to promote

It is important that practitioners maintain access to data and models of the study as form of detailed inventory (LCI) and not only in the form of LCIA results. In effect, this allows you to:

- compare several LCIA methods
- recalculate the indicators in the future with updated characterization methods
- adapt the methods to the adopted methods in the preparation of descaling factors

Similarly, standardization data should be made available in the form of inventories rather than in the form of normation factors.