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DDI8003 – Week 10 - Interpretation

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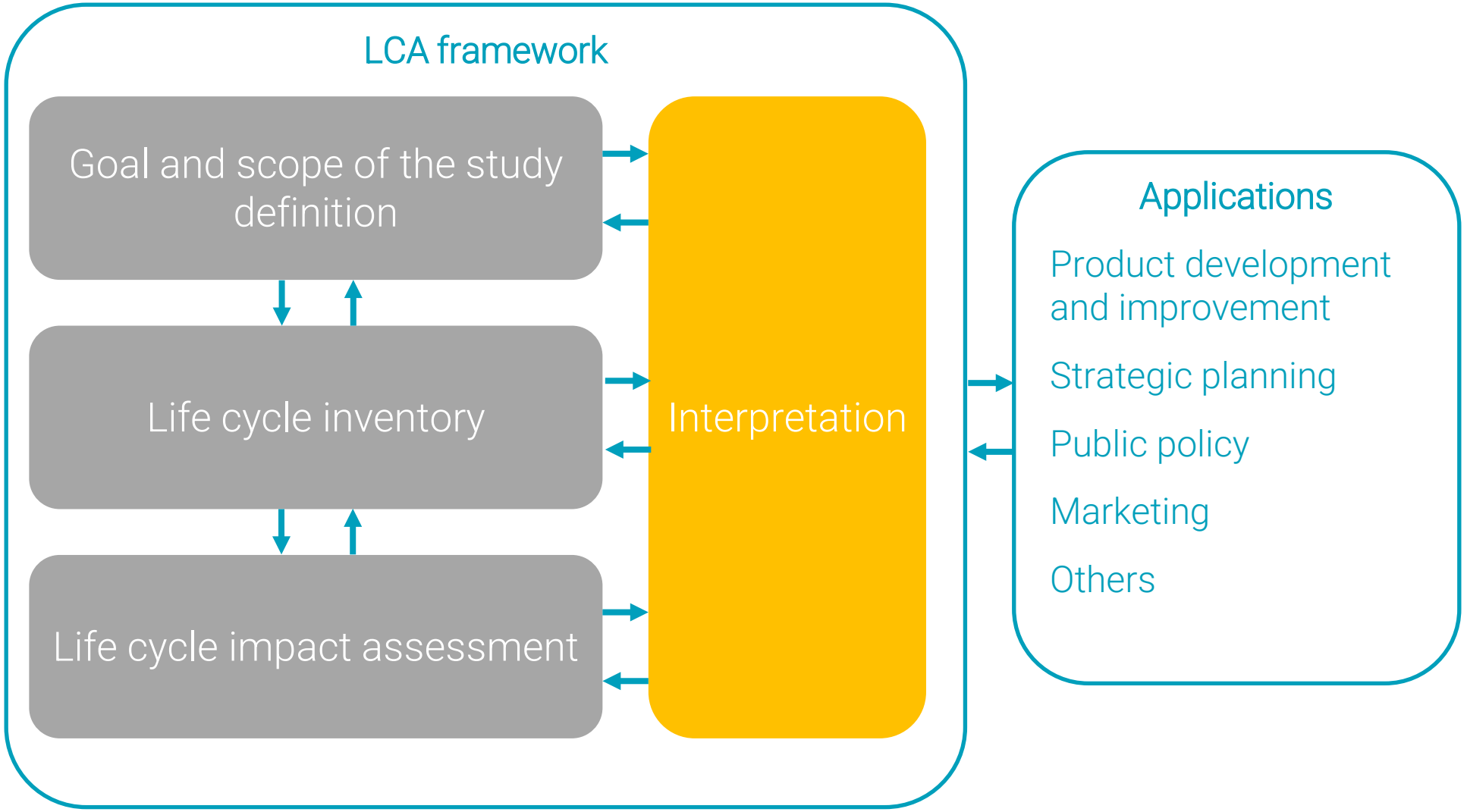
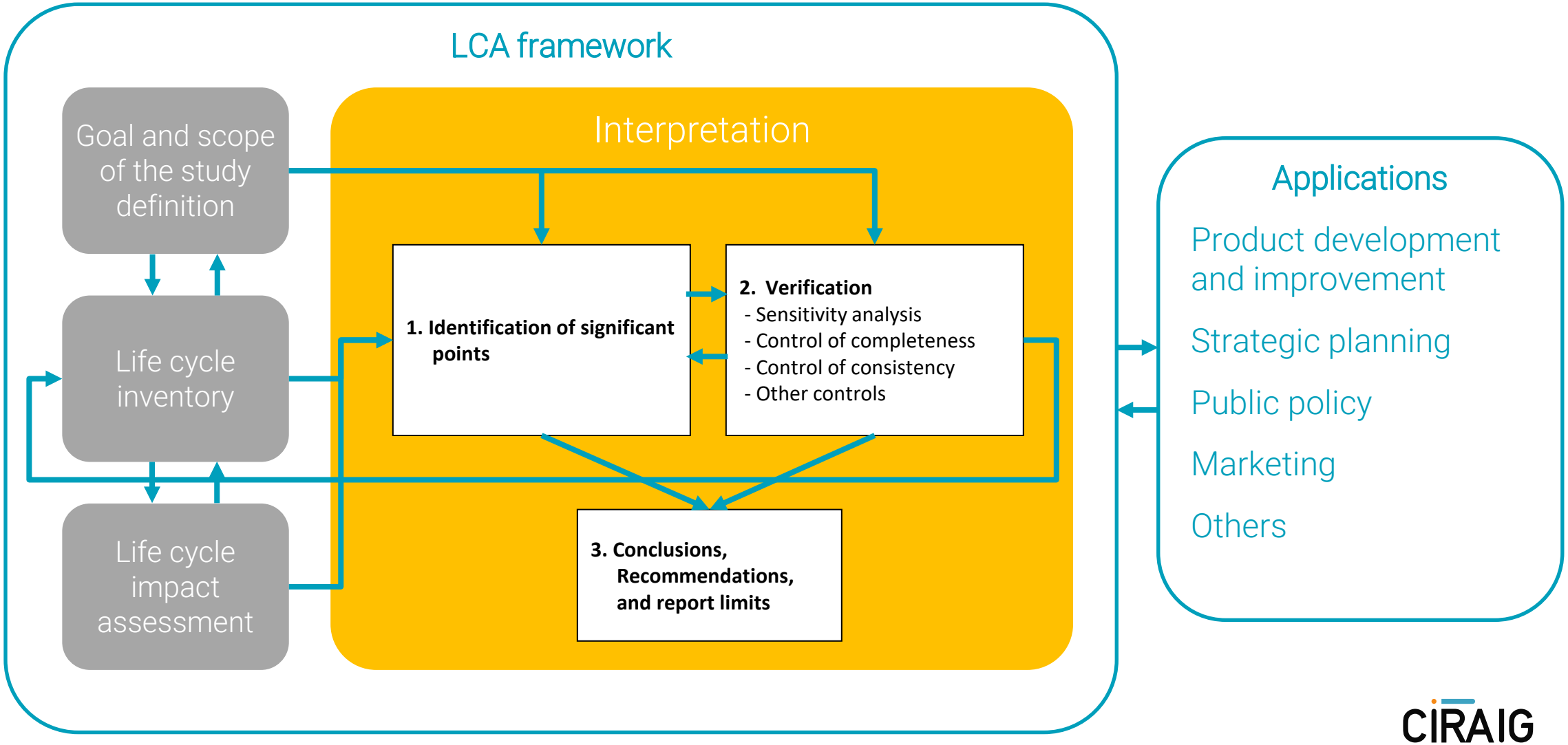
POLYTECHNIQUE MONTRÉAL UQÀM EPFL Hes·so

LCA framework according to ISO 14040



Life cycle interpretation: 3 main steps



Based on ISO 14044 : 2006

Overview of course

1. Interpretations of LCA results
   - **Identification of significant issues / Contribution Analysis**
   - **Verification (sensitivity, completeness, consistency)**
   - **Evaluation of data quality**
2. The critical review process
3. Concepts applied - openLCA

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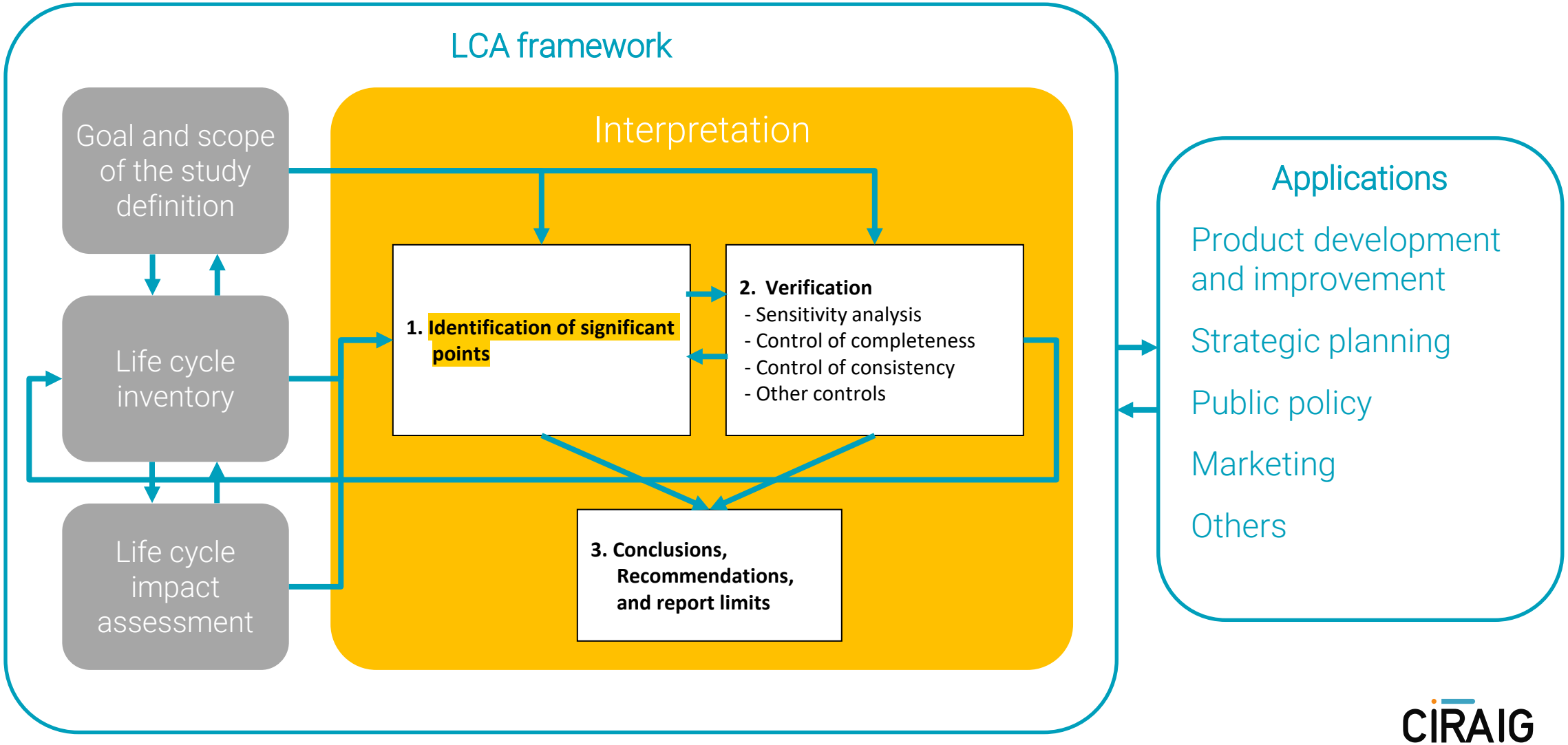
Life cycle interpretation: 3 main steps



Based on ISO 14044 : 2006

Identification of significant issues (ISO 14044 §4.5.2)

Goal: Structure the results from the LCI and LCIA phases in order to help determine the significant issues, in accordance with the G&S

- **Contribution analysis = way of structuring the results**
- **Need to address the implications of the methodological choices, e.g.**
  - Assumptions made
  - Management of multifunctional processes (allocation rules)
  - Process excluded (cutoff rules)
  - Selecting models impact categories and category indicators
  - Role and responsibilities of interested parties such than defined in G&S in relation to the application

ISO 14044 does not specify what those significant issues are

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Contribution analysis

To compare impact contributions at different levels:

- **step of the life cycle (processes or process groups), focusing on:**
  - those that generate the greatest impact

  AND

  - those that offer the greatest potential for reducing the impact
- **LCA phase : inventory, characterization (midpoint, damage, AoP), normalization, weighting**

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Example II: Background - Hand dryers XLERATOR

COMPARATIVE ENVIRONMENTAL LIFE CYCLE ASSESSMENT OF HAND DRYING SYSTEMS:
The XLERATOR® Hand Dryer, Conventional Hand Dryers and Paper Towels

(XLERATOR):

(AIR DRYER):

(Paper Towels):

Objective of the study :

- **Determine environmental impacts over the life cycle when used in the US**
- **Compare impacts between the systems studied**
- **Evaluate the influence of several key characteristics or variables**

Functional unit: to dry 260k pair of hands

Adapted from: http://www.exceldryer.com/PressKit/Green.php

LCIA Impact profile at damage level aggregated into AoP

What is the contribution of…

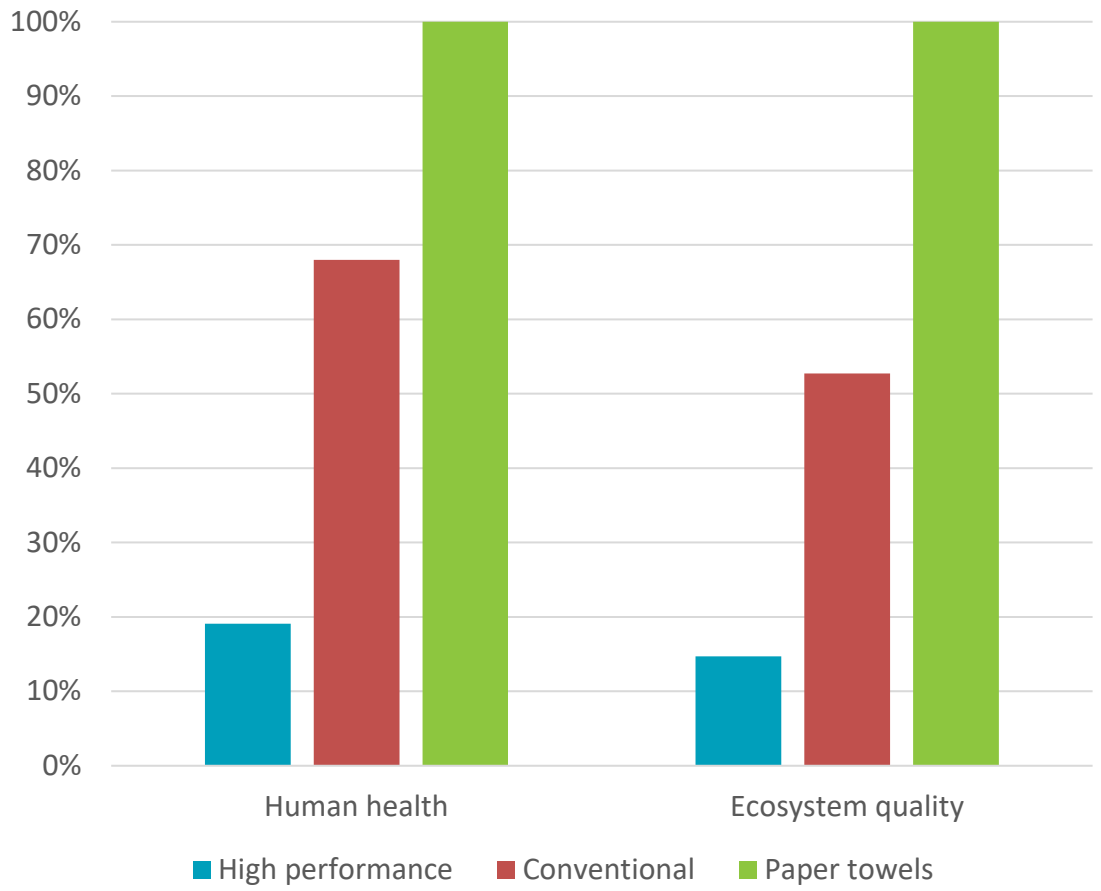
…the different life cycle steps/ elementary processes?

..the different environmental impacts?

…the different elementary flows?

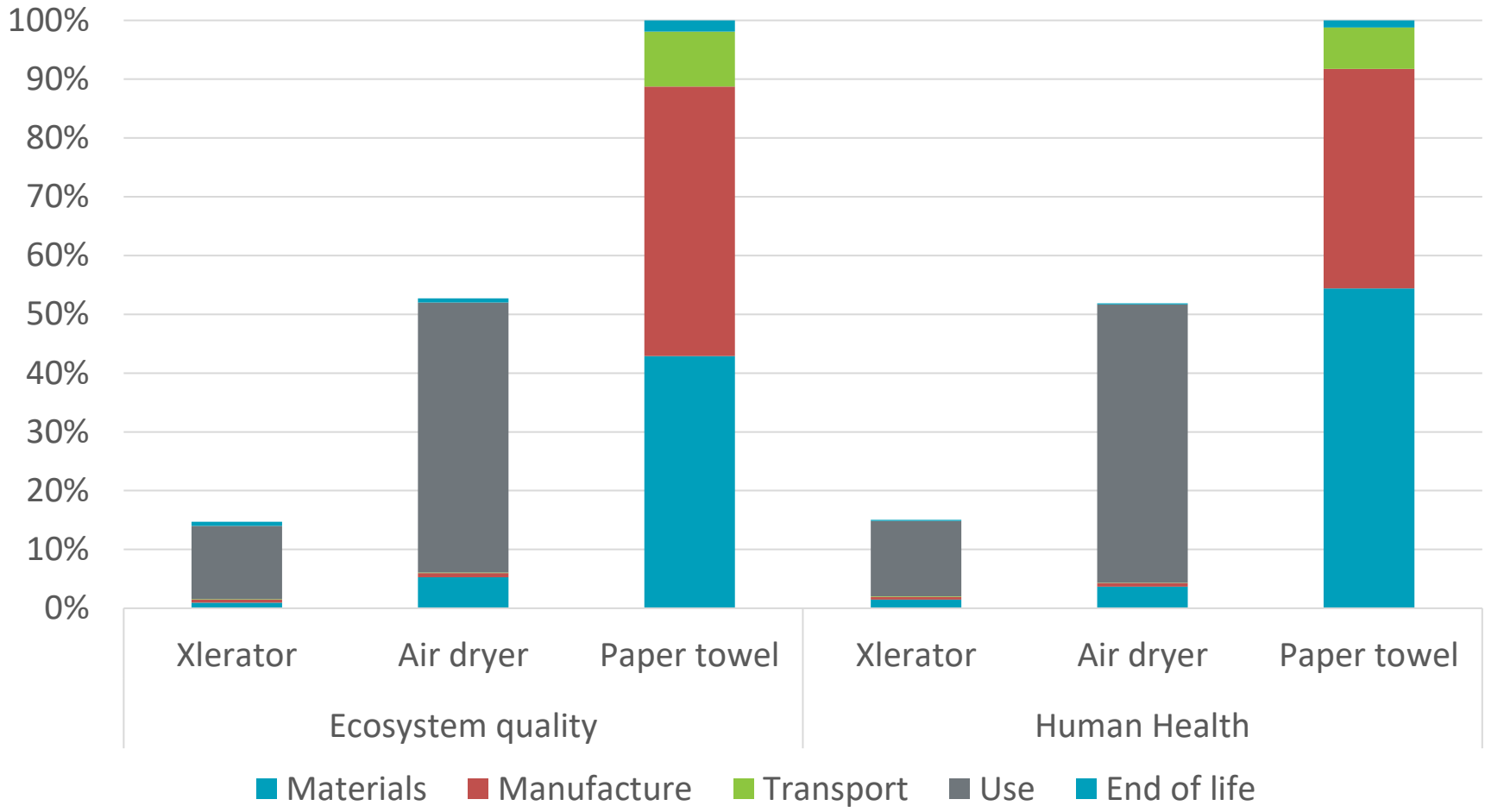
IMPACT World+; UF: 260k pairs of hands

Relative score -> equivalent as UF: to dry 1 pair of hands



Contribution by life cycle stage

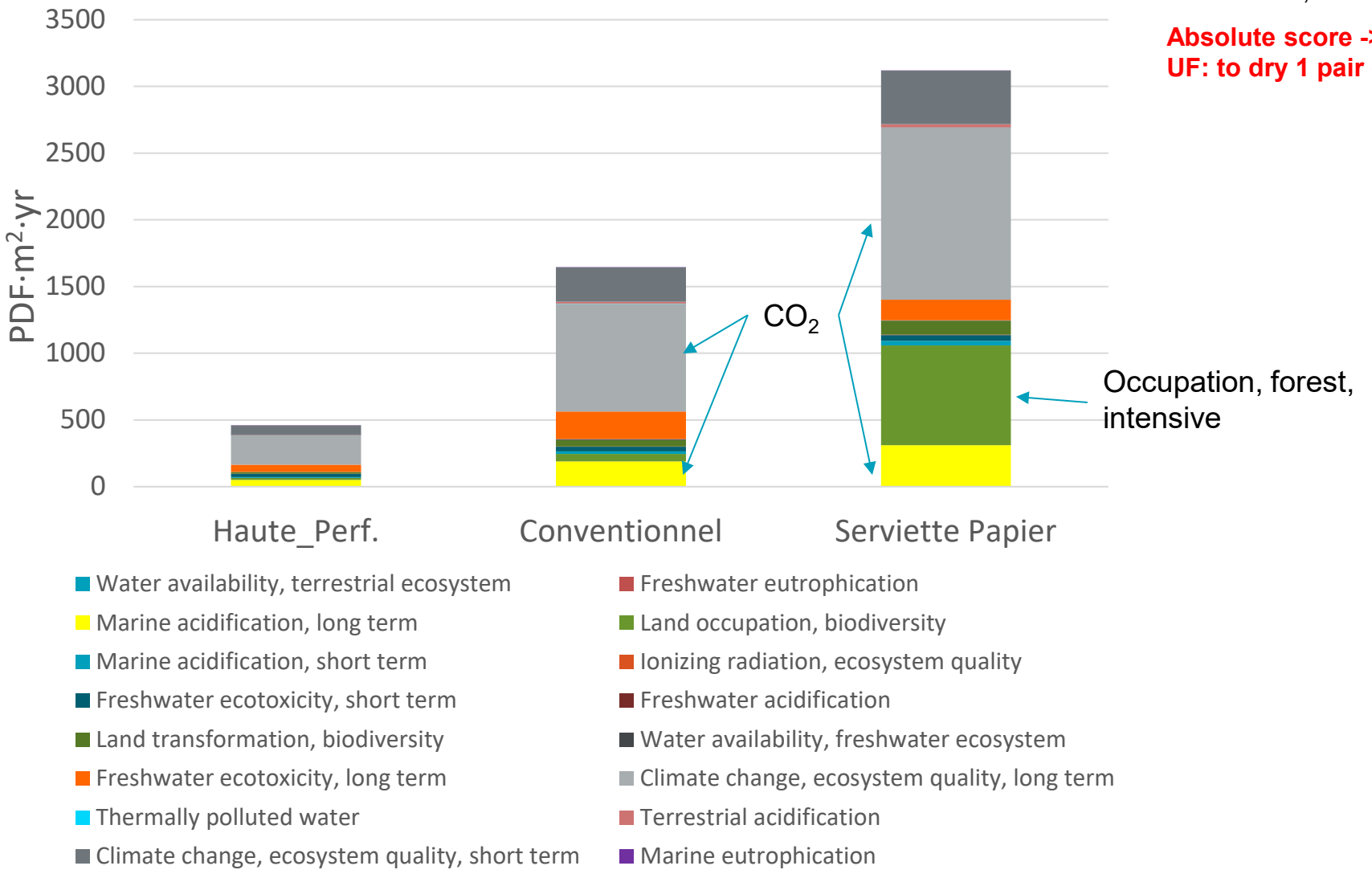
IMPACT World+; UF: 260k pairs of hands



Damage contribution to Ecosystem quality AoP

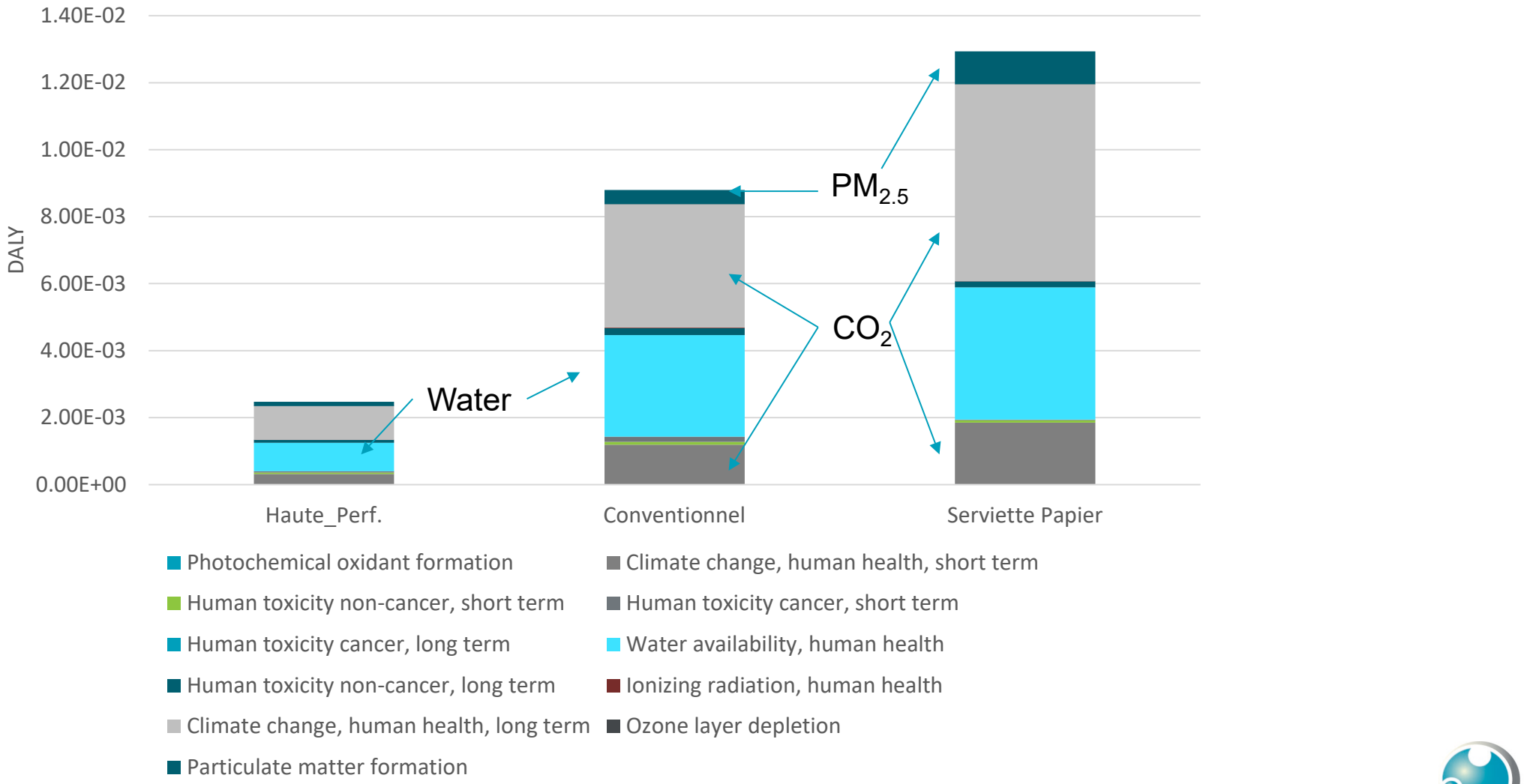
IMPACT World+; UF: 260k pairs of hands

Absolute score -> different from UF: to dry 1 pair of hands



Damage contribution to Human Health AoP

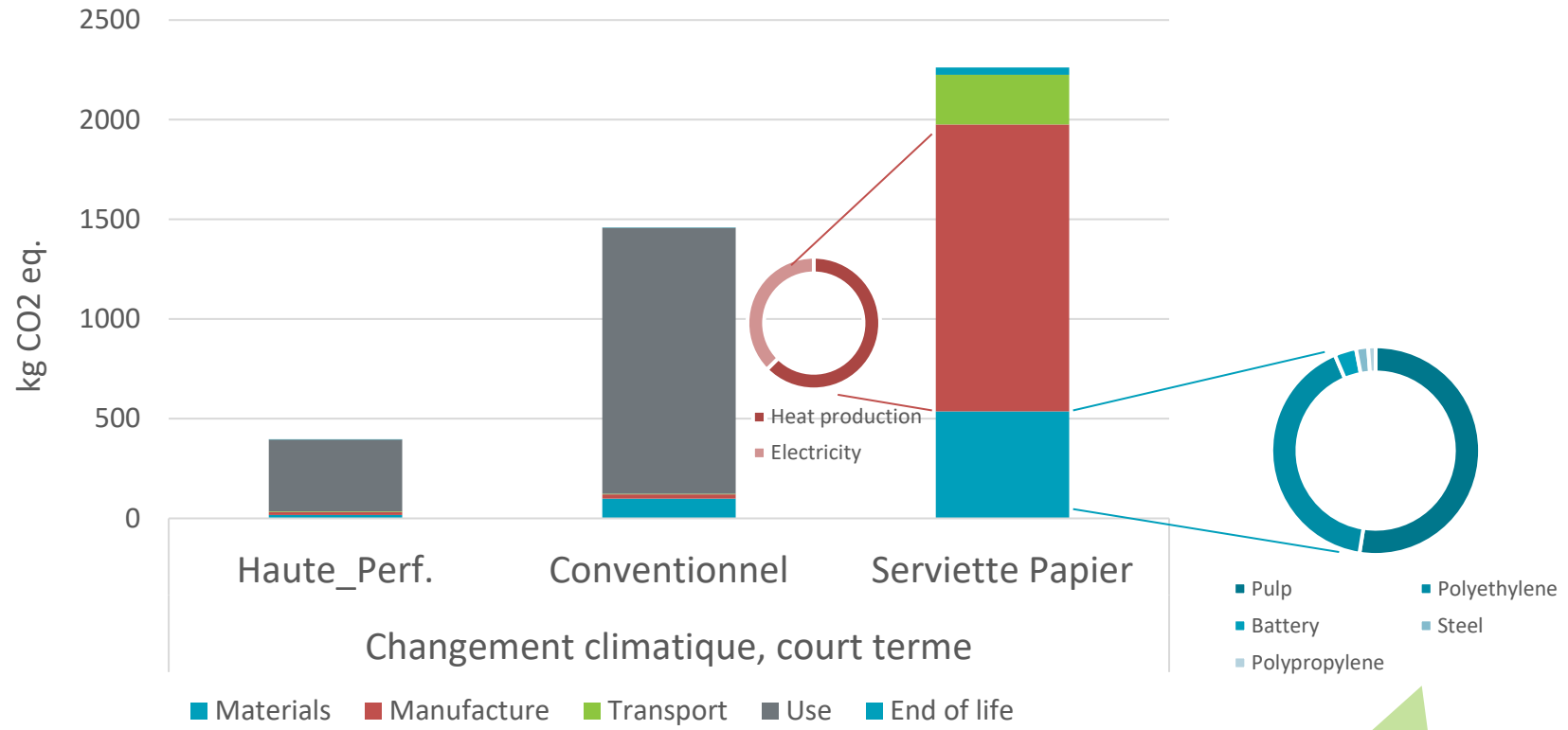
IMPACT World+; UF: 260k pairs of hands



Process contribution to the climate change impact category

Focus on most contributing impact categories

IMPACT World+; UF: 260k pairs of hands



Focus on most contributing processes

Contribution analysis: Why is my system harmful to the environment?

Choose relevant analysis and « tell a logic story »

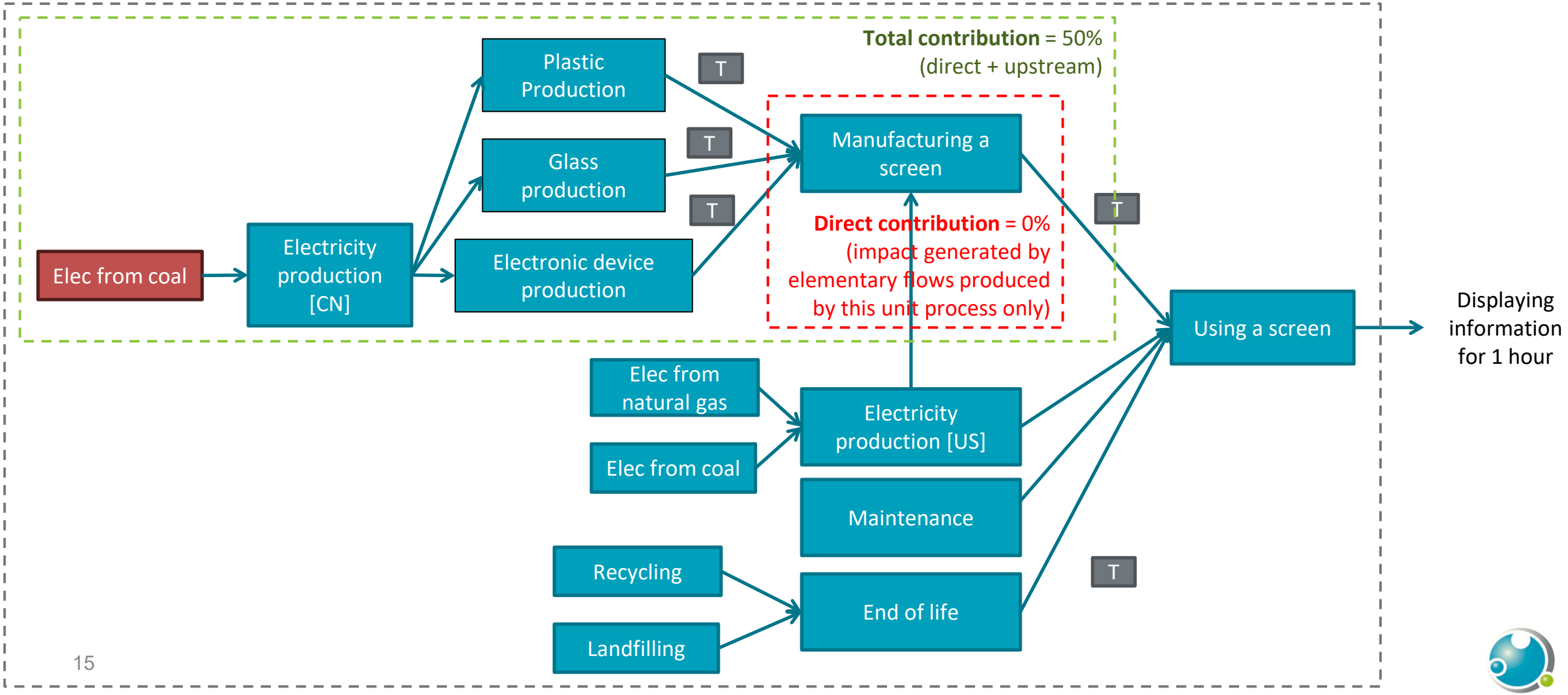
What are the most contributing environmental issues?

How important are my impacts?

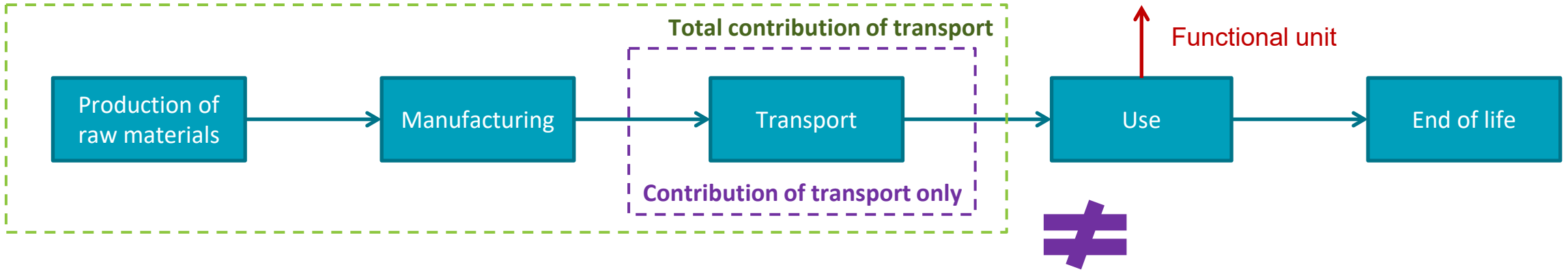
What are the most contributing activities or emissions?

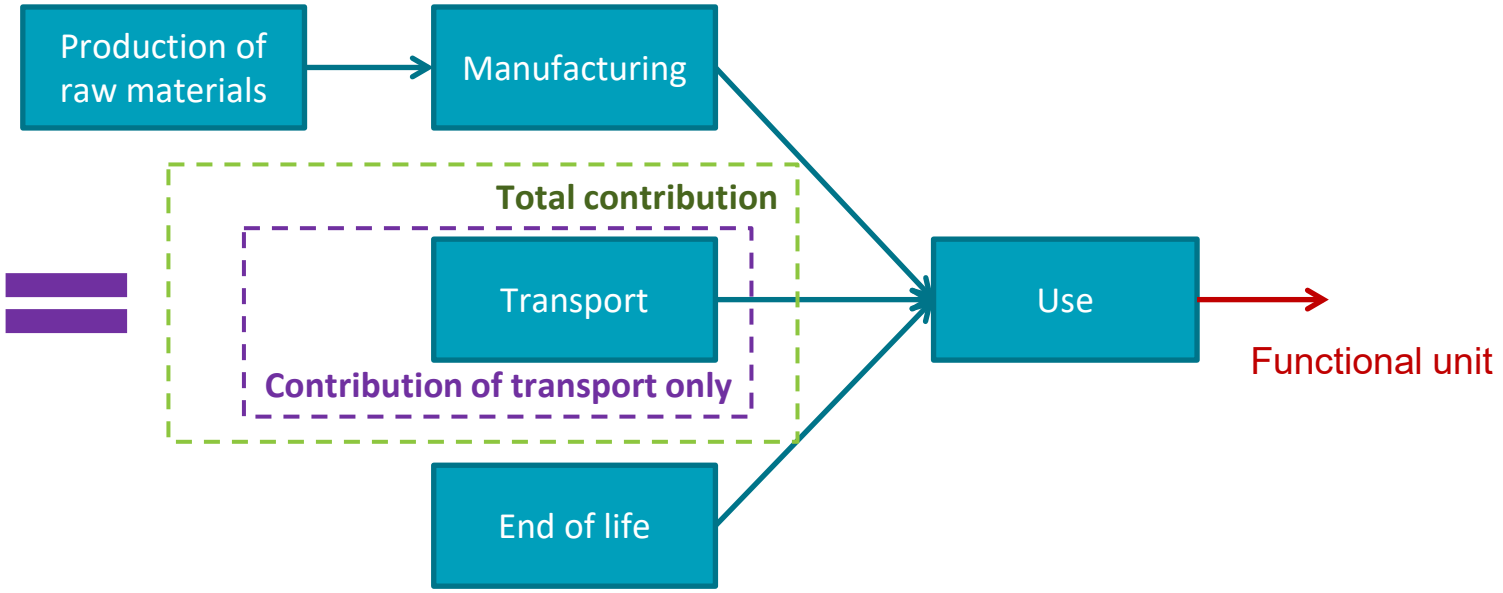
Comparing scenarios /For each scenario	Impact scores per midpoint	Impact score per damage	Impact score per AOP	Impact score normalized	Impact score weighted
Per life cycle stage					
Per elementary process					
Per elementary flow					

Contribution analysis: direct vs total impact contribution



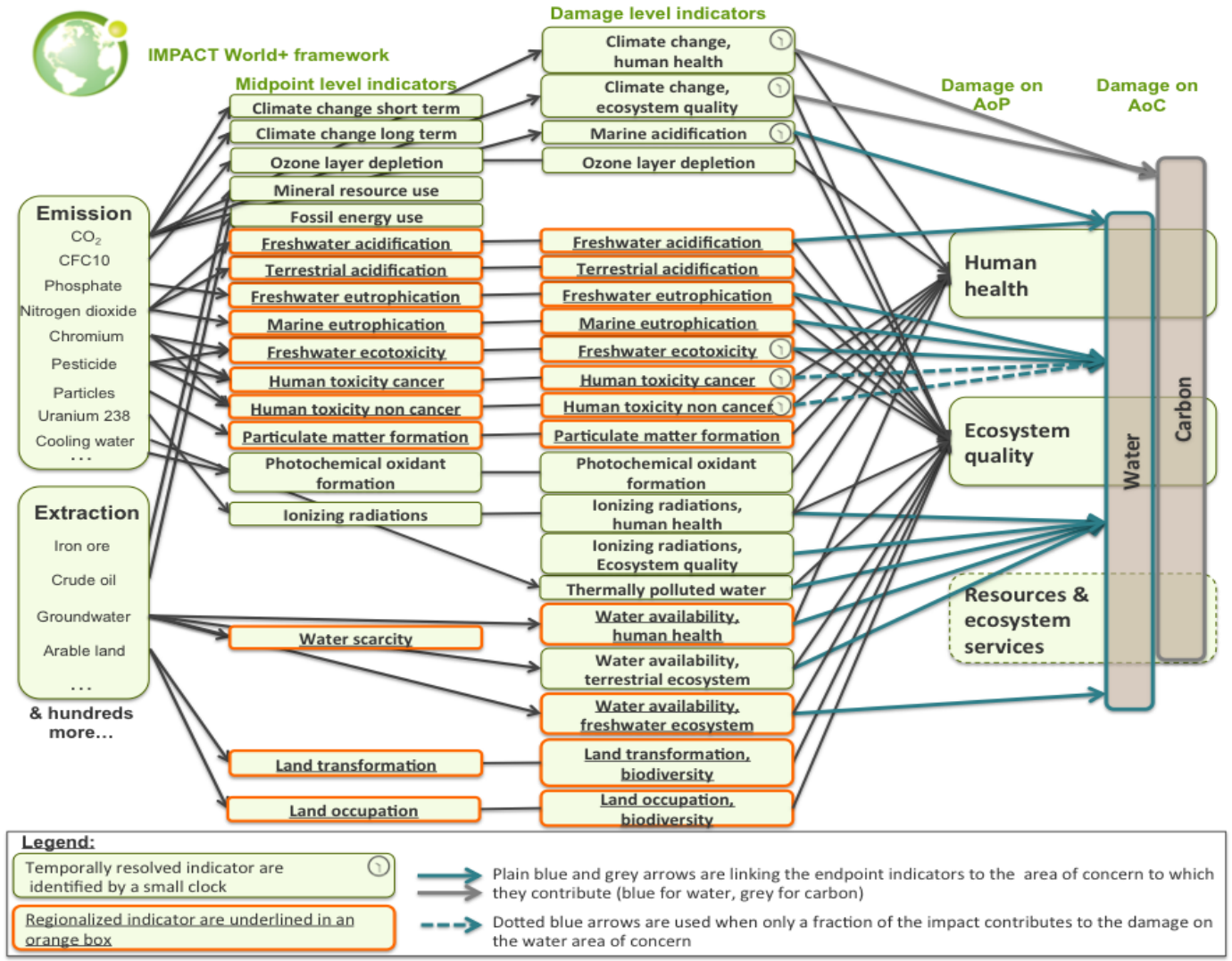
Contribution analysis: the way you structure your model might help interpretation





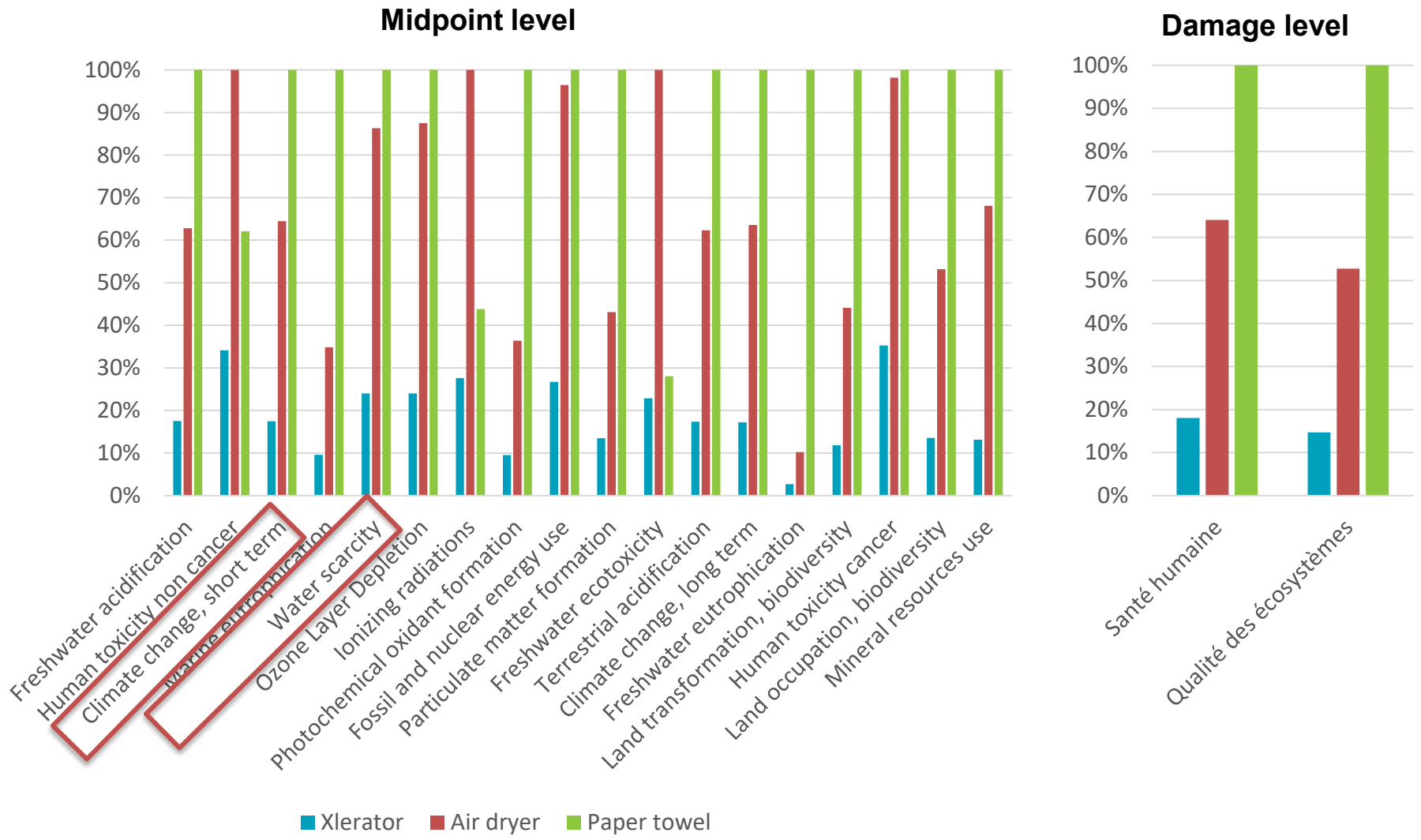
IMPACT World+, expert version

- 18 midpoint impact categories
- 21 damage impact categories
- 3 Areas of Protection
- + 2 Areas of Concern

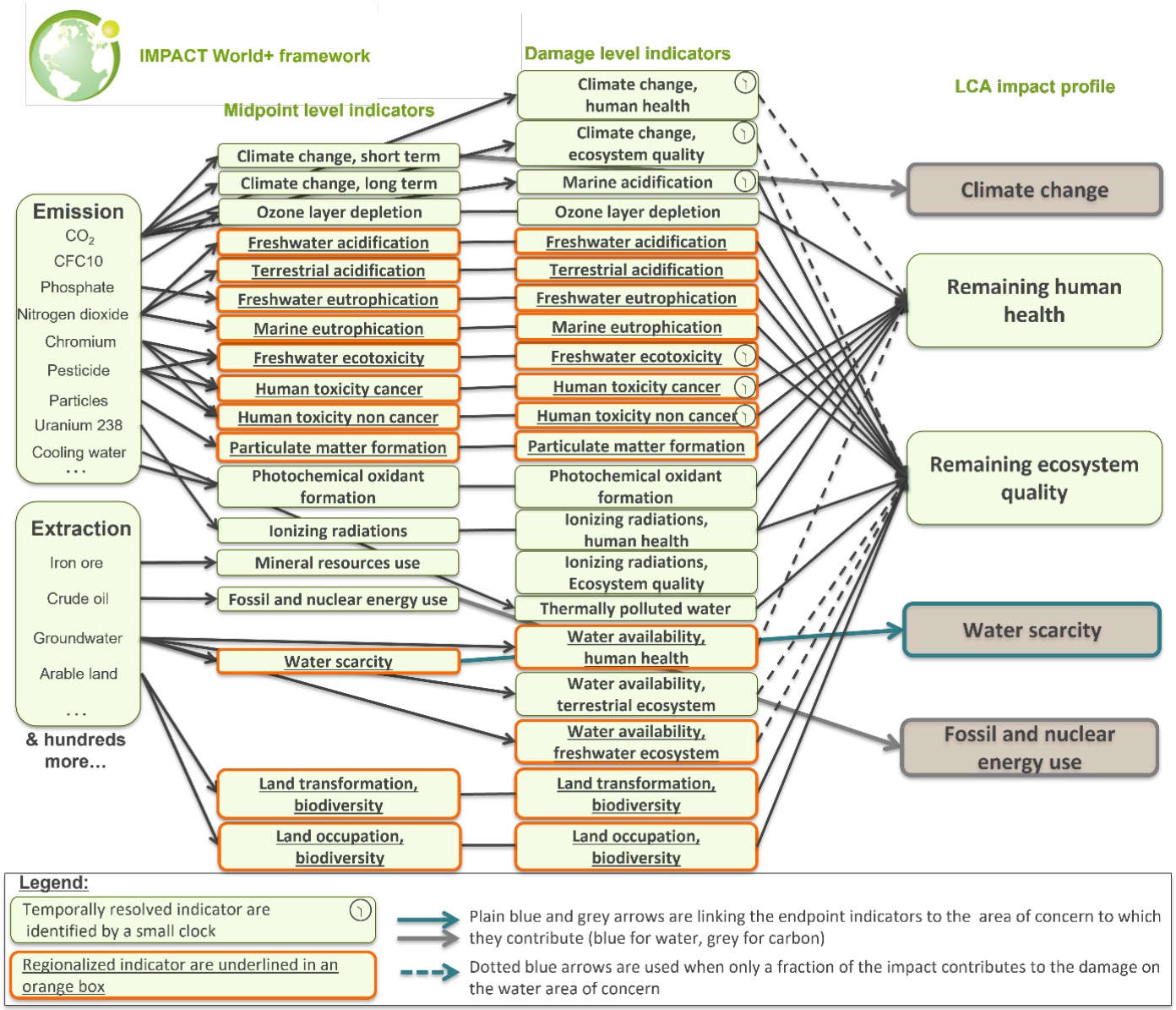


LCIA profiles at
Midpoint level vs Damage level (aggregated into AoP)

IMPACTWorld+; UF: 260k paires de mains

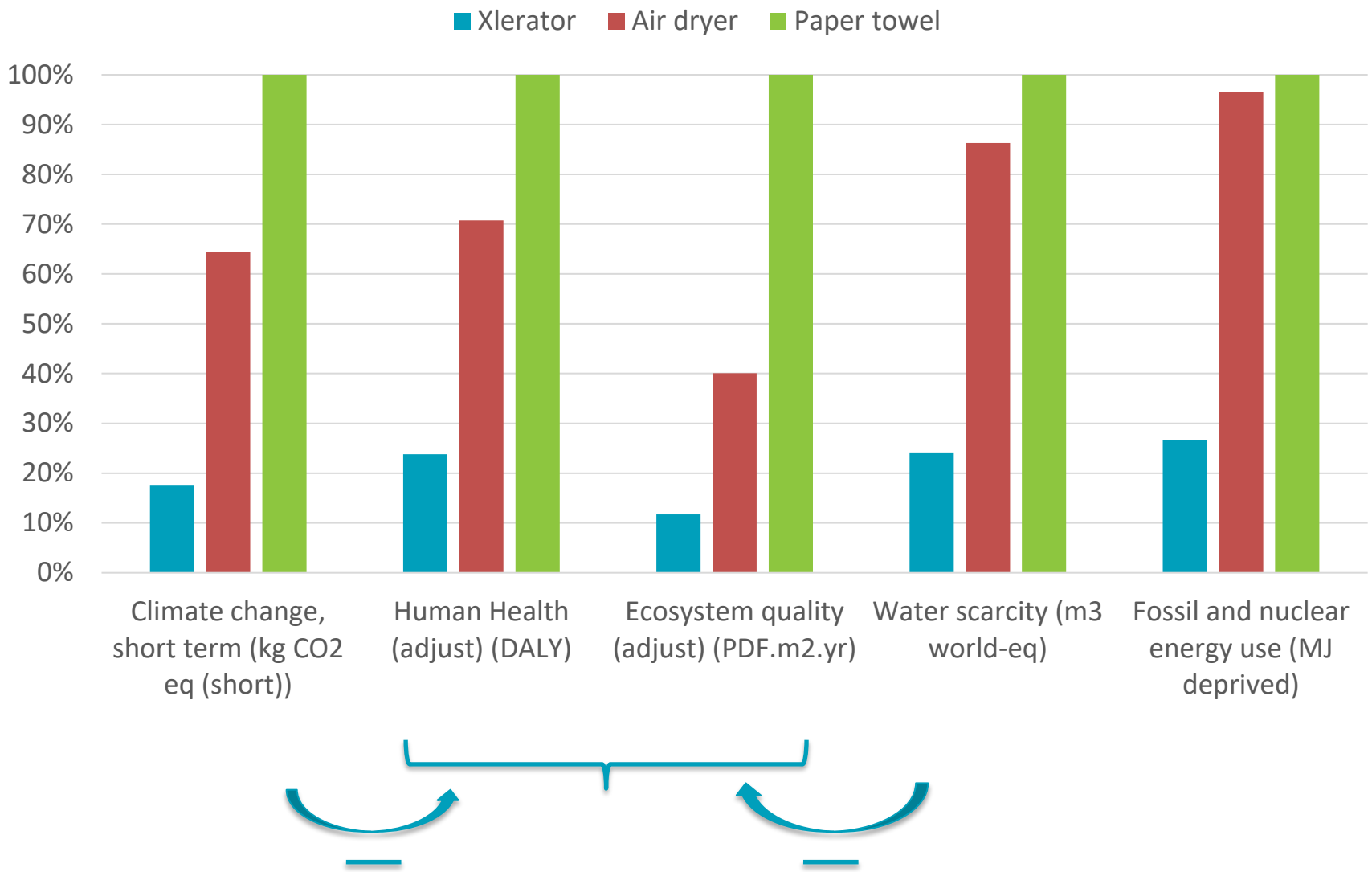


IMPACT World+, footprint version



LCIA Profile: by Areas of Concern & Area of Protection

IMPACT World+; UF: 260k pairs of hands



Determination of significant points and structuring

Other methods:

Dominance Analysis: By using statistical tools or other techniques such as Qualitative or quantitative ranking (*ranking*), significant or outstanding contributions are studied

Influence Analysis: The ability to influence an environmental aspect is examined (e.g. significant improvement possible /slight improvement/ no control possible)

Evaluation of Misstatements: Surprising or unusual deviations are identified (eg, unexpected results, anomalies..)

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Interpretation of LCA results:
Sequence of modeling vs. sequence of interpretation

Goal and scope Inventory Impact assessment

Realization of a LCA (LCA)

Results interpretation

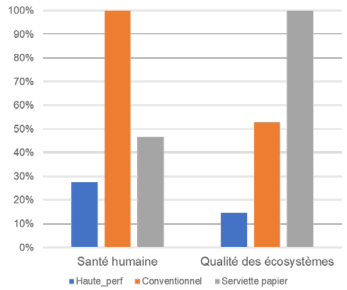
Sequence of modeling…

Goal & scope | Inventory | Impact assessment

Realization of a LCA

Definition of..
- functional unit
- Reference flows
- Key parameters
- System boundaries
- Allocation rules
- Choice of LCIA method
- Etc.

- Primary data collection
- Choice of LCI Database
- "Mapping" of the intermediate flows - generic processes
- Etc.



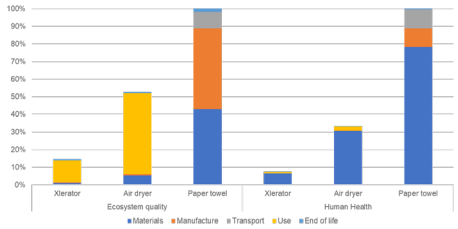
…sequence of interpretation

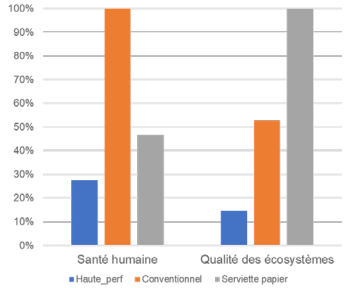
Goal & scope | Inventory | Impact assessment

Realization of a LCA

Sensitivity analysis:
- Functional unit
- Electric mix
- paper Source 0-100% recycled
- User Profile
  - Time drying
  - Nb. towelpairs hands
- etc.

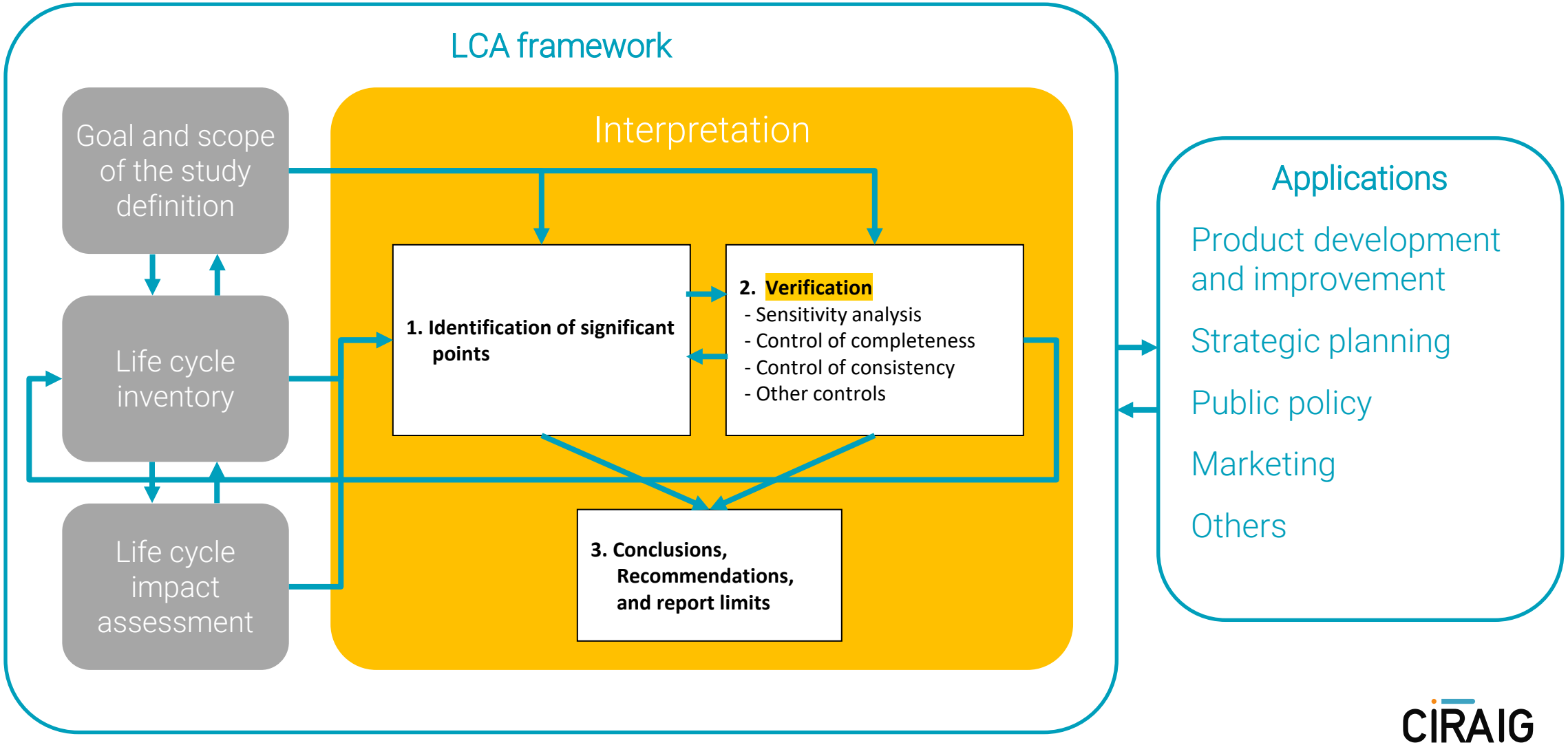
Analysis of contribution by:
- stage of the life cycle (processes or process groups),
- phase of the LCA: inventory, characterization (problem and damage)





Results interpretation

Life cycle interpretation: 3 main steps



Based on ISO 14044 : 2006

Verification (ISO 14044, §4.5.3)

Goal

- **Establish and enhance confidence and the reliability of the results of the LCA study, including the significant issues identified**

- **The verification step shall account for the G&S of the study, and the final intended use of the results**

→ different requirements in relation to the type of LCA (ISO 14044, §5) :

1. internal LCA (§ 5.1)
2. LCA communicated to a third party (§ 5.2)
3. Comparative LCA disclosed to the public (§5.3)

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Verification (ISO 14044)

Three types of verifications:

- **Sensitivity analysis**
  - Estimate the effects of the choices made regarding methods and data on the outcome of a study
- **Control of Completeness**
  - Ensure that relevant information and data required for the interpretation are available and complete
- **Control of Consistency**
  - Determine whether the assumptions, methods and data are consistent with the purpose and scope of the study

Supplemented by:

- **uncertainty analysis** (required for a comparative LCA disclosed to the public)
- and **data quality analysis**

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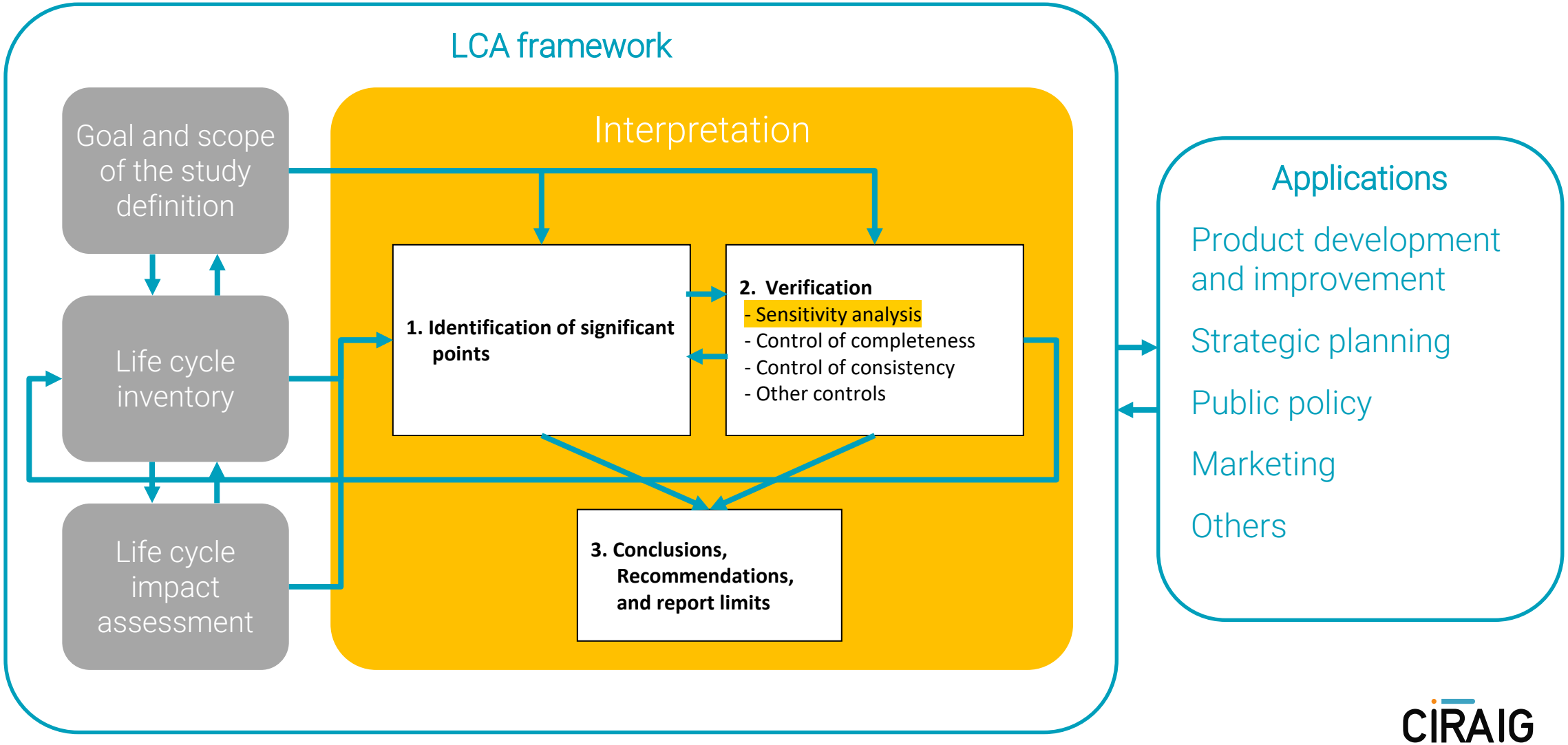
Life cycle interpretation: 3 main steps



Based on ISO 14044 : 2006

Sensitivity analysis

" *Systematic procedure used to estimate the effects of the choices made regarding methods and data* on the outcome of a study "(ISO 14044)

Aims to determine the **influence** of variations in assumptions, methods and data on the **results**

→ **test the robustness of your conclusions**

- **check sensitivity of the most significant issues of the LCA**
- **the need for a sensitivity analysis can be predetermined by the G&S of the study**

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Sensitivity analysis

Example of assumptions, methods or data that can be analyzed in a sensitivity analysis:

- **Uncertain inventory data**
- **Judgements and assumptions regarding data**
- **Rules of allocation;**
- **Cut-off criteria;**
- **Boundary setting and system definition (temporal, supply chain ...)**
- **Selection of impact category**
- **Assignment of inventory results (classification)**
- **Calculation of category indicators (characterization)**
- **Data for normalization**
- **Data for the weighting**

Examples from your projects?

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Sensitivity analysis on two types of parameters

"Estimating the effects of the choices made regarding methods and data on the outcome of a study"

- **Continuous settings** (emission factors, characterization factors, component mass, transportation distance):
  - **How the change of a numeric value influences the results?**
- **Discontinuous settings** (choice of processes, choice of allocation method, choice of impact methodology):
  - **How the change of a normative choice influences the results?**

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Sensitivity analysis - continuous settings

1. We can modify the value by a quantity representing the uncertainty on the parameter *(eg. Standard deviation, min-max)*

2. We can modify all the parameters once at the time by a given percentage
   - **Results can be organized in a "tornado diagram"**
   - **Advantage: More useful to identify the parameters that have to be enhanced in a modeling**

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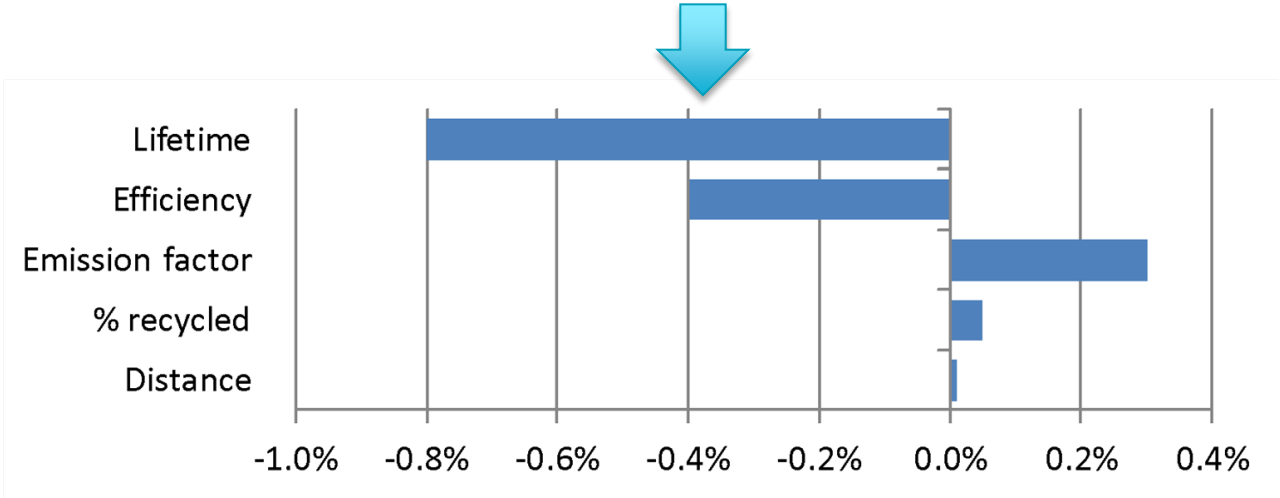
Comparative LCA of Hand drying
Sensitivity analysis – continuous settings (example)

Parameter	Value basic	News value	Result (Kg CO_2eq)	Difference (%)	Ranking
BASELINE			**10**	-	
Efficiency	70%	(70 * 1.01)%	9.96	-0.40%	2
Distance	100 km	101 km	10.001	0.01%	5
% recycled	30%	(30 * 1.01)%	10.005	0.05%	4
Lifetime	3 years	(3 * 1.01) years	9.92	-0.80%	1
Emission Factor	5g / kWh	(5 * 1.01) g / kWh	10.03	0.30%	3

- Results calculation after a small change in the values (eg. 1%)
- Results can be organized in "tornado diagram"



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Sensitivity analysis– discontinuous settings

- For the discontinuous parameter, the previous approaches cannot be used
- The most common approach consists in comparing discreet **scenarios**
- It is important to choose **relevant scenarios**...

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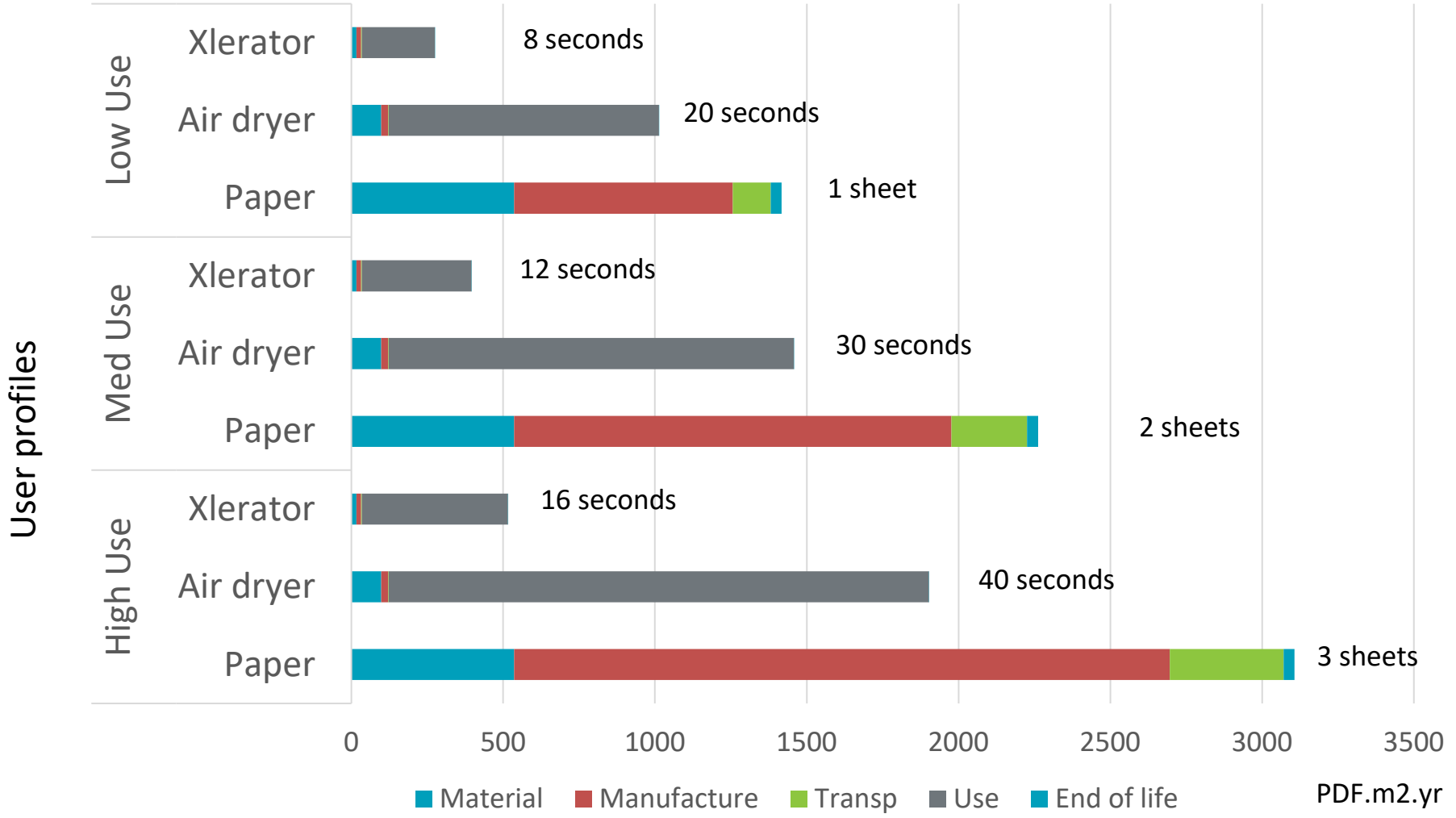
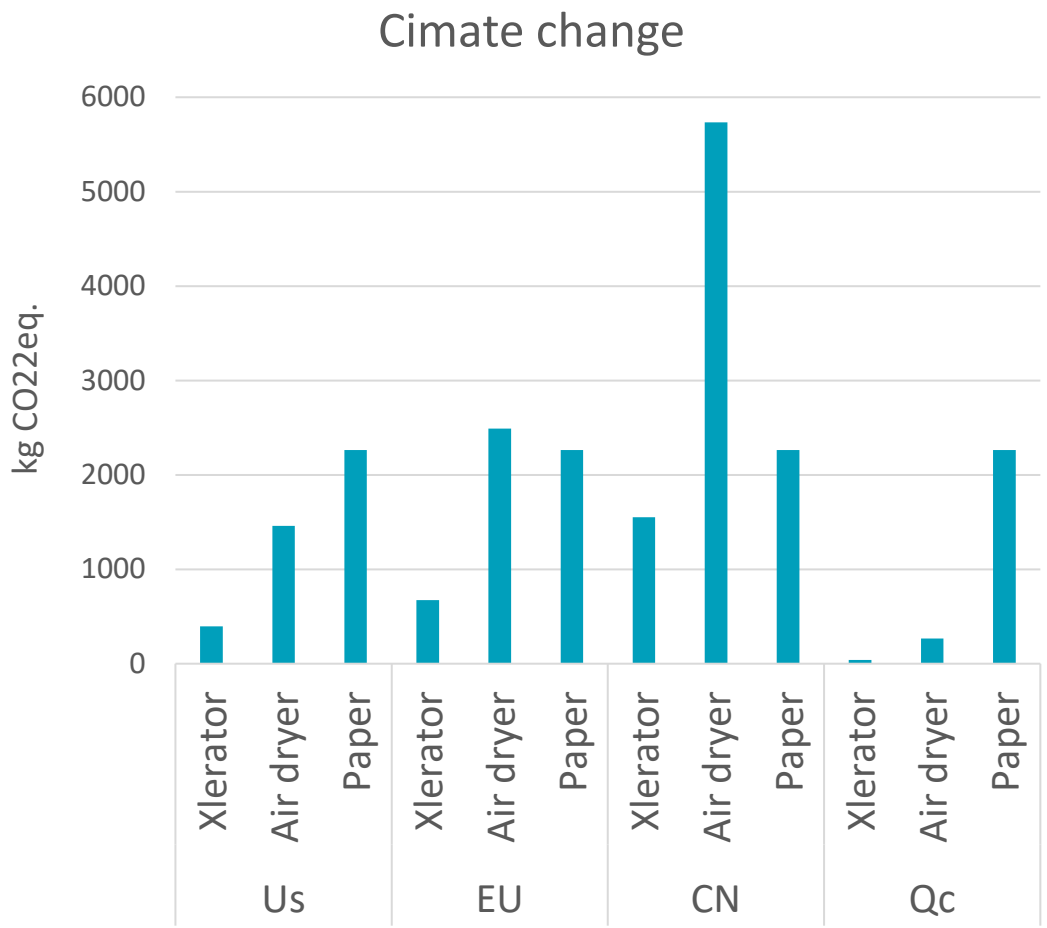
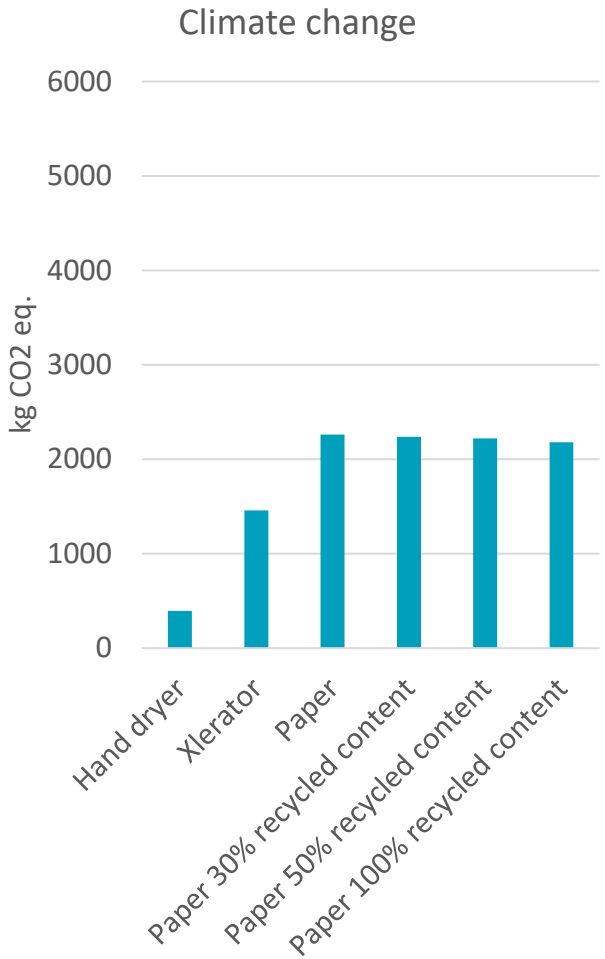
Comparative LCA of Hand drying
Sensitivity analysis- Discontinuous settings (example)



Comparative LCA of Hand drying
Sensitivity analysis- Discontinuous settings (example)

Scenario analysis on electricity mix supply and recycled paper



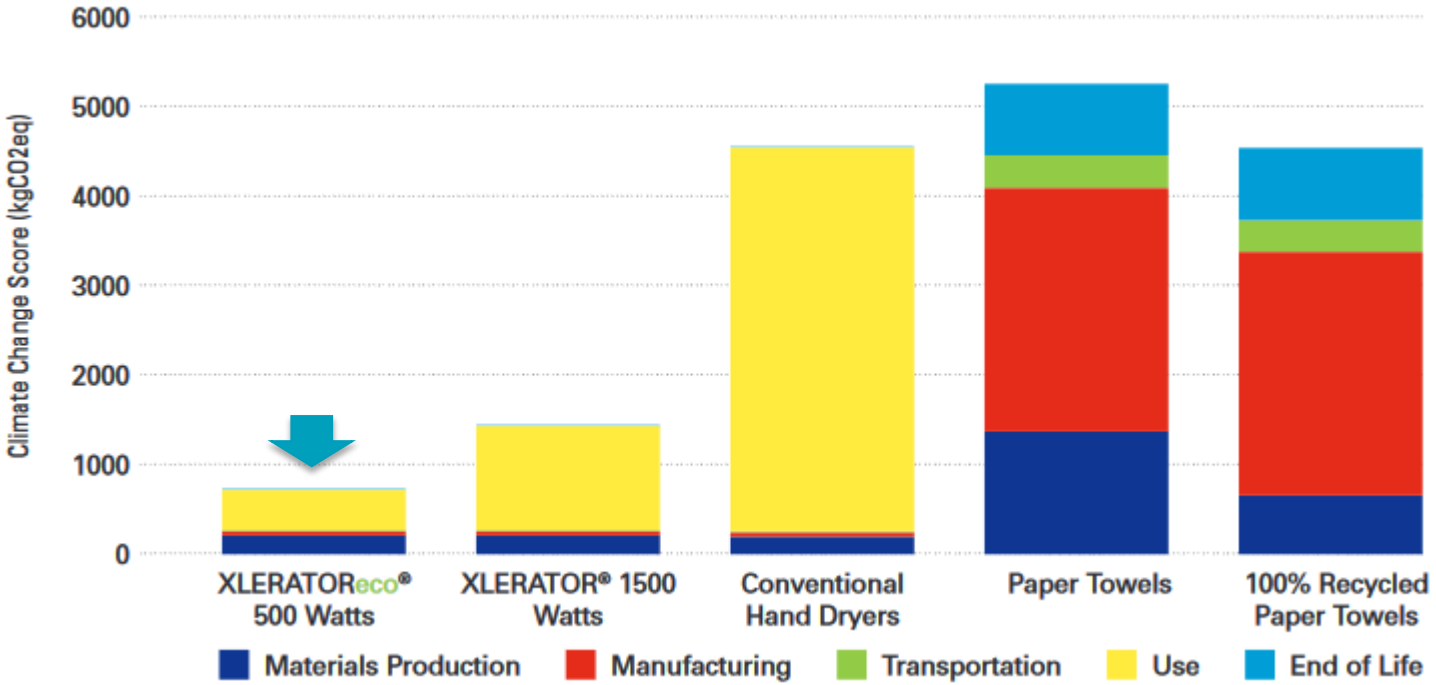


Some other sensitivity analysis - Examples

Other examples:

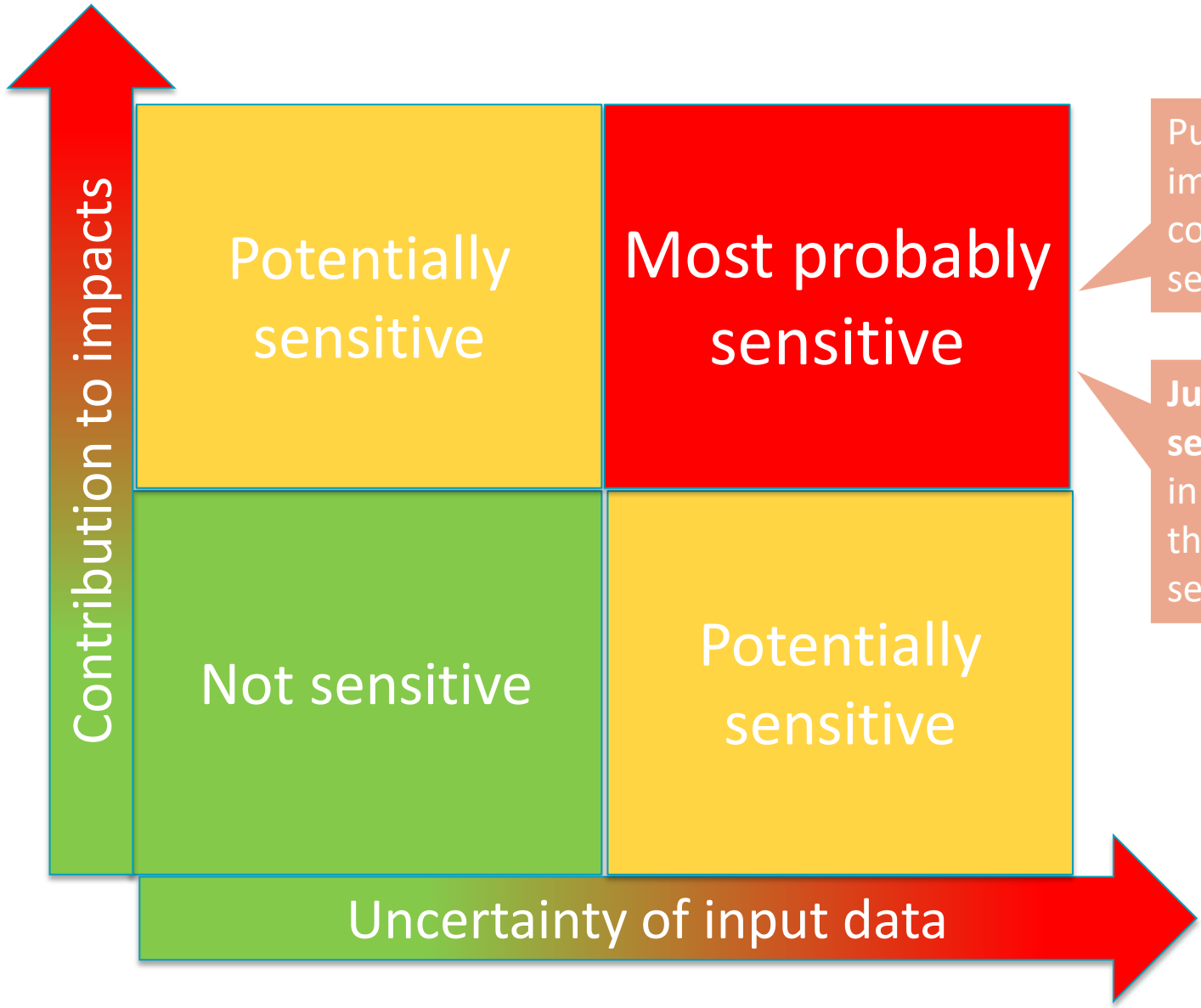
- Include an antibacterial in the "dried-hand" systems
- Displacement of heating/ Accentuation of the air conditioner linked to the production of heat
- Test another impact assessment methodology
- …

Few years later… a new model with improved use phase



Access to the full study
https://www.exceldryer.com/sustainability/

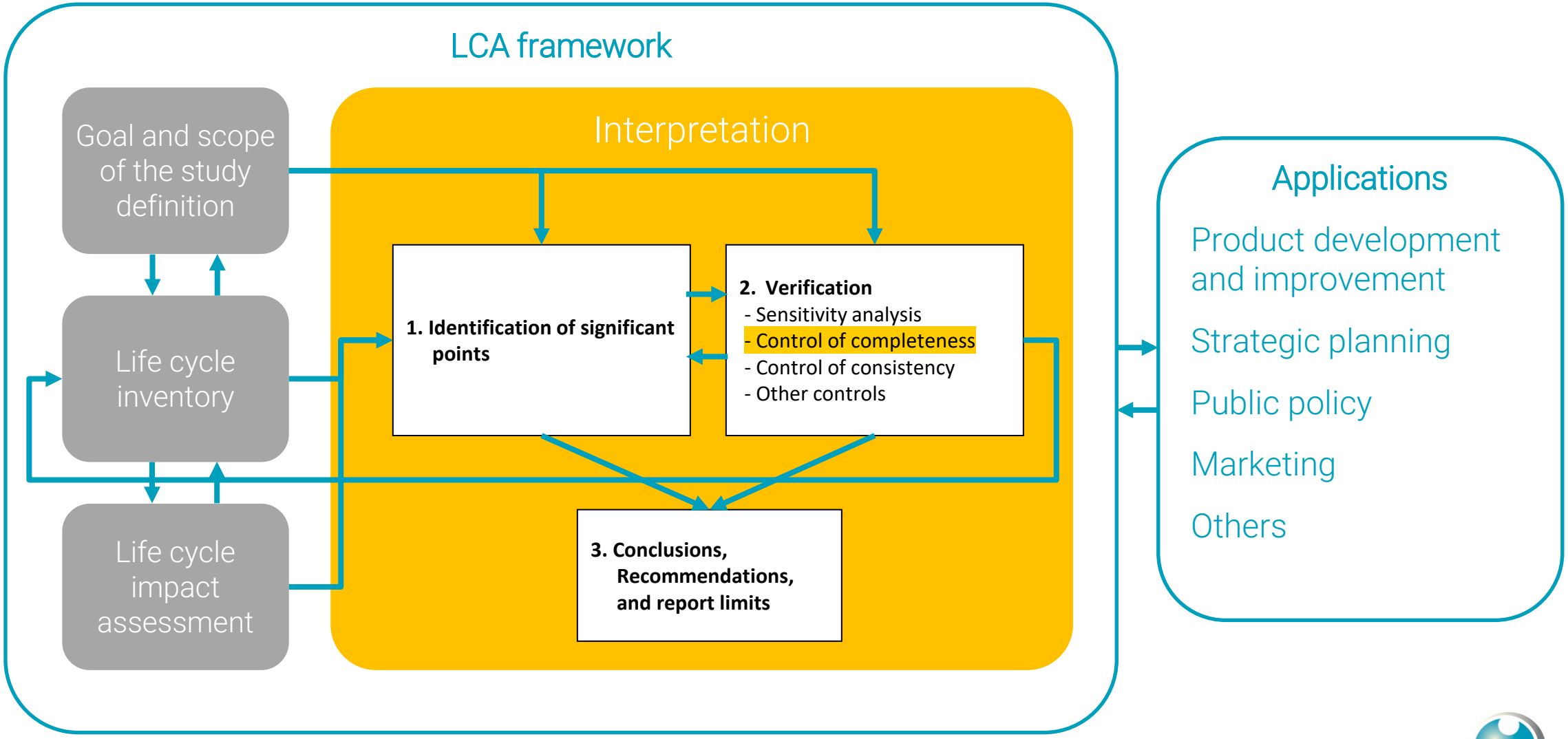
How to prioritize your efforts based on sensitivity?



Put your efforts on improving your data collection where it's sensitive!

Justify the choice of sensitivity analysis! Test in priority parameters that are most probably sensitive

Life cycle interpretation: 3 main steps



Based on ISO 14044 : 2006

Control of completeness

Goal:

- **Ensure that relevant information and data required for the interpretation are available and complete**

If missing or incomplete information (*data gaps*)… you have to look if it is necessary to meet the objective of the LCA.

- **If this information is not essential , it is necessary to indicate why.**
  - Then proceed with the verification
- **If this information is essential to determine the significant points:**
  - Review the previous phases (LCI and LCIA) or adjust the definition of the purpose and scope of the study.

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Control of completeness

Sources of missing or incomplete information (data gaps)

The practitioner:

- **Do not know that an elementary process should have been included in the product system;**
- **Has no information on the flows associated with an elementary process;**
- **Has information only on a few elementary flows for an elementary process;**
- **Has information only on aggregated elementary flows**
- **Do not know that an elementary flow contributes to an impact category;**
- **Do not know the characterization factor for a substance; and/or not appropriate weighting factors**
- **Do not cover a potential environmental issue (ex: impacts of plastic leakage into the environment)**

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Control of completeness

Summary

elementary processes	option A	entirely	Required action	option B	entirely	Required action
Energy production	X	Yes		X	Yes	
Energy distribution	X	Yes		X	No	recalculate
Transport	X	?	Check Inventory	X	Yes	
Treatment	X	No	Check Inventory	X	Yes	
Packaging	X	Yes		-	No	Compare to A
use	X	?	Compare to B	X	Yes	
End of life	X	?		X	?	Compare to A

X: data entry available
-: no data entry

Taken from ISO 14044: 2006

Control of completeness

Suggestion to improve the completeness:

- Parameter estimation / proxies
    - Using data obtained from similar technologies
    - Mass balance to assess the missing mass
    - Average data
    - Estimated data (expert judgment)
- Using other databases
- Using Economic input-output matrices (EIO-LCA)

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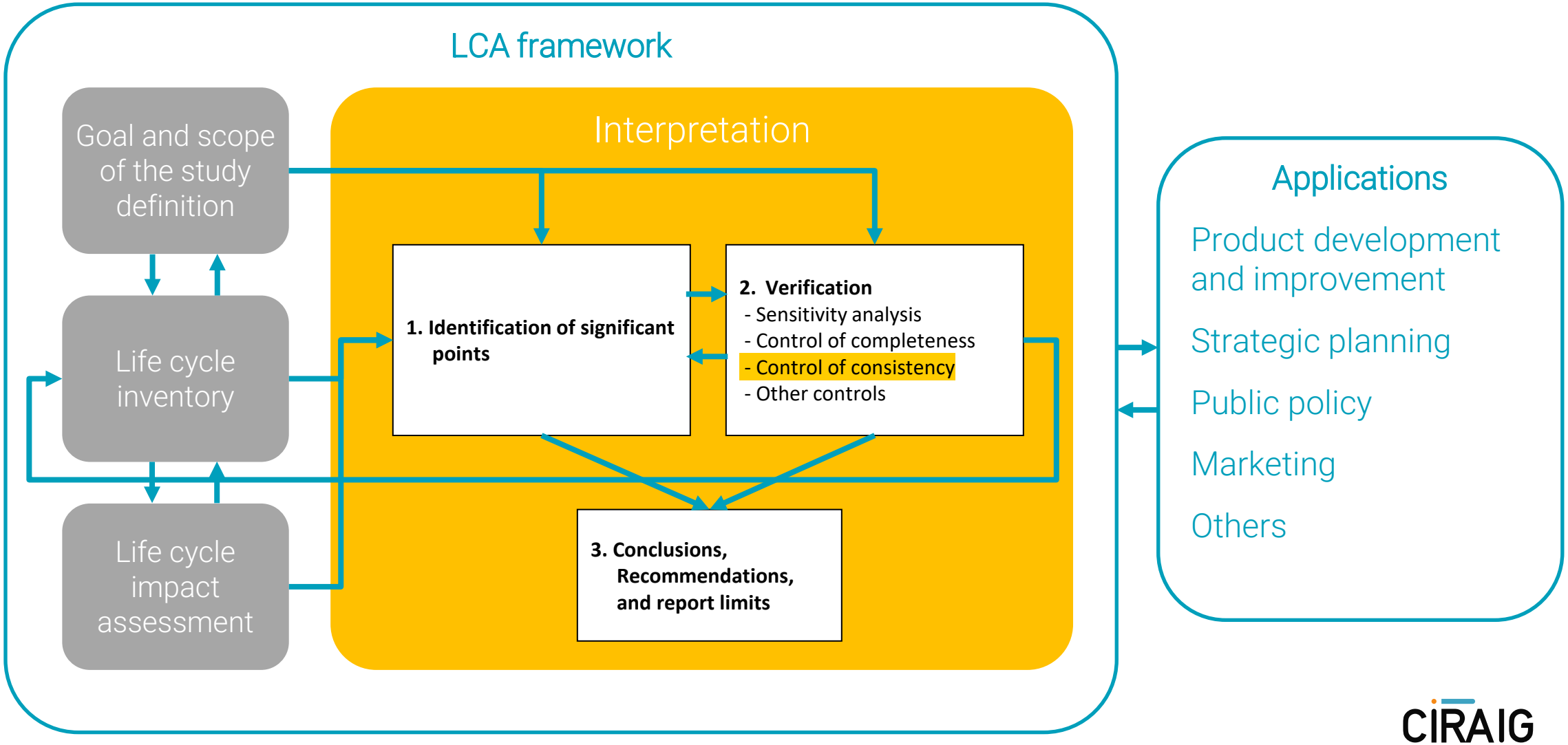
Life cycle interpretation: 3 main steps



Based on ISO 14044 : 2006

Control of consistency

Objectives:

- **Determine whether the assumptions, methods and data are consistent with the purpose and scope of the study**
- **For comparative analysis, to ensure that assumptions, methods and data were selected and applied consistently to various options.**

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Control of consistency

Examples of inconsistencies in comparative LCA:

- differences sources of data:
  - **Option A is based on literature while Option B is based on primary data;**
- differences precision of data:
  - **for option A, a tree of processes and a description of a very detailed process are available while option B is described as a system of cumulative black boxes;**
- differences technological representativeness :
  - **data for Option A is based on an experimental process (eg a new catalyst with a process yield higher on a pilot plant), whereas data for Option B are based on a widely available technology .**

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Control of consistency

Examples of inconsistencies in comparative LCA:

- differences temporal representativeness:
  - **data for Option A describe a recently developed technology while Option B is described as a mix of technologies including plants recently built and older plants;**
- differences geographical representativeness :
  - **Data Option A describe a representative European technology mix, while option B is representative of a single european country with a high level of environmental protection, or a single plant;**
- Differences on indicators of categories:
  - **For Option A, GWP is calculated over 100 years when we used a calculation base of 500 years for option B.**

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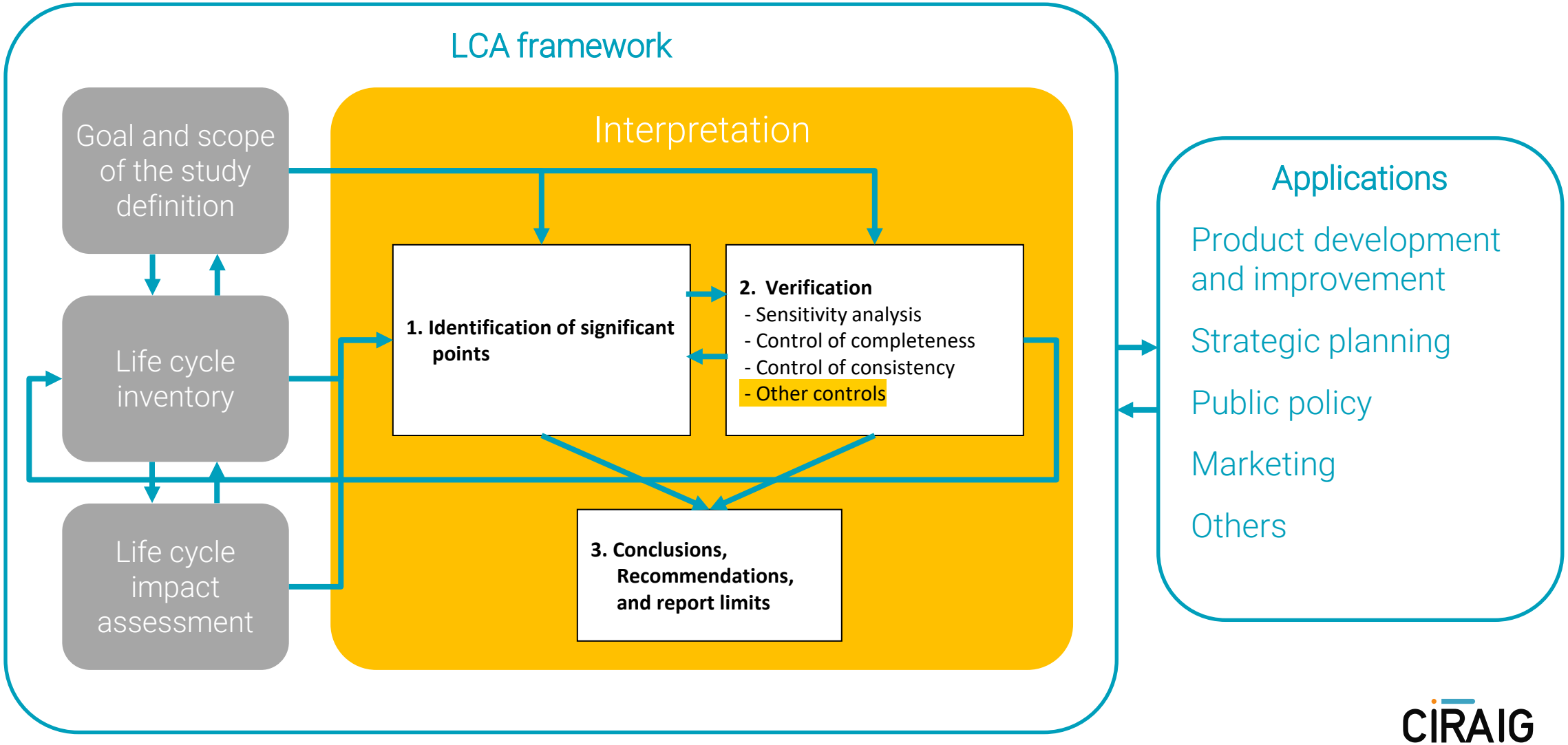
Control of consistency

The result of a consistency check (generic example for a comparative LCA):

Control	option A		option B		Compare A and B	Action
Data source	Literature	okay	primary data	okay	Inconsistency	Target of the study ? no action
Data Accuracy	good	okay	Low	Objectives and scope of the study unfulfilled	Inconsistency	Review B
Age of data	2 years	okay	1 year	okay	Consistency	No action
Temporal representation	recent	okay	real	okay	Consistency	No action
Geographical representation	Europe	okay	France	okay	Consistency	No action
Technological representation	State of the art	okay	pilot plant	okay	Inconsistency	Target of the study ? no action

Life cycle interpretation: 3 main steps



Based on ISO 14044 : 2006

Quality of the data and uncertainties LCA

According to ISO 14044, the DQR (data quality requirements) Should cover:

- **The time (1), (2) geographical and (3) technology, (4) the accuracy, completeness and representativeness, (5) the consistency and reproducibility of the methods used, (6) the data sources and their representation, and (7) the uncertainty associated with the information**

Examples of DQI (data quality indicators) Found in the literature:

- **Accuracy, bias, completeness, data distribution, precision, uncertainty, applicability, consistency, identifying anomalies, peer review, representativeness, reproducibility, stability, transparency, data collection method, limitations, references**

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Simplified approach to evaluate data quality in relationship of contribution analysis - example

How good is?

Flows quantification ↓ *Choice of processes* ↓

Step lifecycle	Data Quality		Contribution	Collection
	Reliability	Representative-ness		
Manufacturing	4	3	2-8%	
Distribution	3	2	<1%	
use	4	2	3-11%	
Maintenance	3	2	82-90%	
End of life	4	3	1-5%	

Intermedary flow

elementary process

Element judged as priority

Element judged as no priority or completed

Simplified approach to evaluate data quality in relationship of contribution analysis - example

Data quality analysis

The reliability of the results and conclusions of the life cycle modeling depend on the quality of the study's inventory data. It is important to ensure that the information meets certain requirements that are in line with the objectives of the study.

Though ISO does not propose a particular method, two criteria that impact inventory quality were selected to assess the data:

- **Reliability**: Pertains to the data sources, acquisition methods, and verification methods. Reliable data has been verified and measured in the field. The criterion chiefly refers to flow quantification.
- **Representativeness**: assesses the geographic and technological correlations. Does all of the data reflect reality? Data is representative when the technology is directly related to the field. This criterion chiefly refers to the choice of processes used when modeling the system.

An ideal situation would require the highest level of reliability (i.e. all primary data) and representativeness (i.e. use of exact technology in the correct geographical context) for all contributing processes. Such a situation rarely arises in life cycle assessment. In this study, best available data was used but as one of the study's objective was to identify the gaps in knowledge for future studies, unreliable or unrepresentative data were accepted. Such data were flagged in the limitation or recommendation section.

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Simplified approach to evaluate data quality in relationship of contribution analysis - example

Table 3-13 : Reliability and representativeness data quality criteria

Score	Reliability criteria
1	Data was measured or calculated on the field – this data meets the highest criteria of reliability
2	Data stems from assumptions based on some field measurements or calculations OR data stems from the literature or from unverified documents provided by TOTAL. This data is deemed to be of sufficient reliability.
3	Unverified data based on assumptions OR expert judgment. This data is deemed usable but should/could be improved in terms of reliability.
4	Data grossly estimated. This data doesn't meet the reliability criteria.
Score	**Representativeness criteria**
1	On field data.- this data meets the highest criteria of representability
2	Good geographical/technological representativeness. – This data representativeness is deemed sufficient
3	Data represents the same process or materials but from a different technology – This data is deemed usable but data should/could be improved.
4	Inadequate geographical and/or technological representability. The data is not easily accessible, use of a proxy – this data does not meet the representativeness criteria.

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Overview of course

1. Interpretations of LCA results
   - **Identification of significant issues / Contribution Analysis**
   - **Verification (completeness, sensitivity, consistency)**
   - **Evaluation of data quality**
2. The critical review process
3. Concepts applied - openLCA

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Critical review

" *Process used to ensure consistency between an LCA study and the principles and requirements specified by the International Standards dealing LCA* "(ISO 14044)

In general, critical reviews are optional, EXCEPT in the case of a comparative assertions to be disclosed to the public

Type LCA	Need a critical review
1. internal LCA (§5.1)	-
2. LCA communicated to a third party (§ 5.2)	Optional (by an expert or panel)
3. Comparative LCA disclosed to the public (§5.3)	Committee of at least 3 members (experts and stakeholders)

Critical review

The use of a critical review should ensure that

1. the methods used to carry out the LCA are **consistent with the International Standard**,
2. the methods used to carry out the LCA are **valid from a scientific and technical** standpoint,
3. the **data used are appropriate and reasonable** in relation to the study objectives,
4. **interpretations reflect the limitations** identified and the objectives of the study,
5. the study report is **transparent and consistent**.

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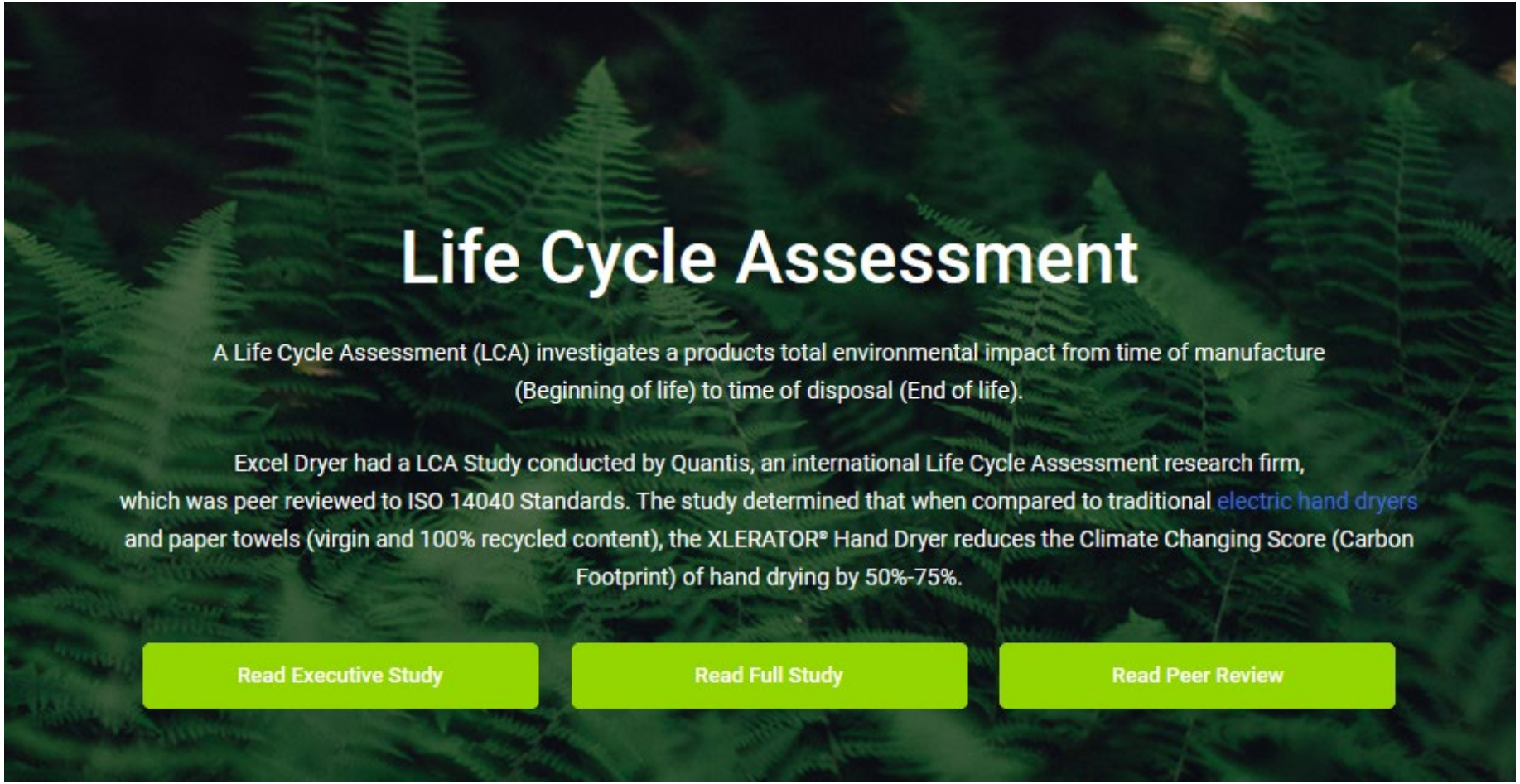
Example of peer review report: hand dryer



https://www.exceldryer.com/sustainability