Conceptual Model for Life Cycle Sustainability Assessment

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Introduction and Objectives

Life cycle sustainability assessment is a new field of application of life cycle assessment together with life cycle costing and social life cycle assessment. The purpose of the study was to identify and to make a review of literature relevant to formulate a conceptual model for life cycle sustainability assessment (LCSA). The purpose of the model is to systematize and illustrate approaches to LCSA results calculation on the basis of the purpose of the assessment, the number of decision-makers, the level of assessment (micro, meso or macro), etc. The LCSA is understood according to the following formula:

LCSA = LCA + LCC + S-LCA

Materials and Methods

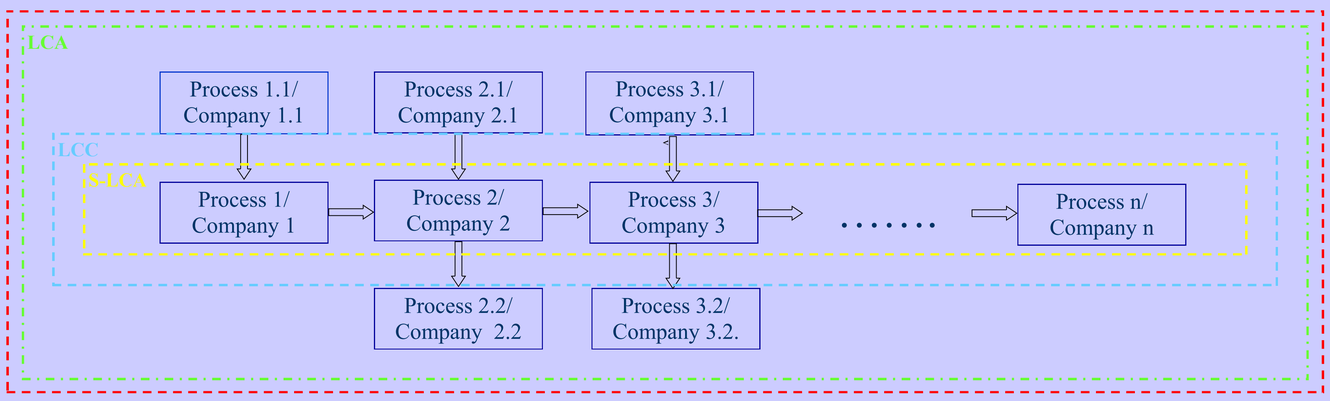
The study began with identifying the science fields, which could contribute both to the implementation and the development of a consistent methodology for LCSA. The following areas of interest were identified as relevant to contribute to the implementation and the methodology development for an integrated assessment of environmental, economic and social aspects in a life cycle perspective:

- utility theory and valuation of preferences (contingent valuation, willingness to pay, etc.),
- decision analysis,
- mathematics (including scoring, weighting, aggregation functions, composite indexes, game theory etc.),
- social choice theory,
- planning in the supply chain, etc.

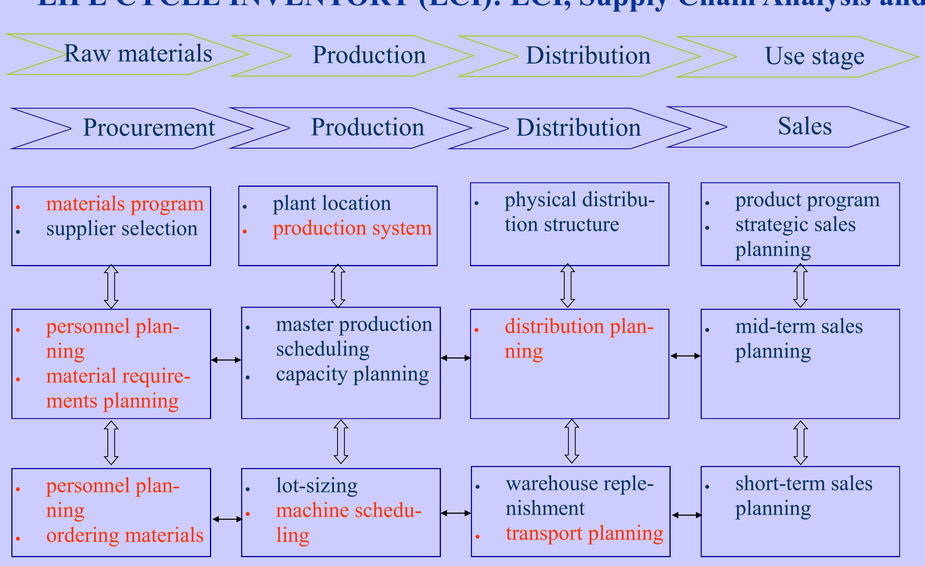
The study relies mainly on secondary sources of information: books and articles and is based on a literature review of those.

Results & Discussion

GOAL & SCOPE DEFINITION: Ideally System Definition the Same for LCA, LCC and S-LCA (- - - - - - - -)



LIFE CYCLE INVENTORY (LCI): LCI, Supply Chain Analysis and Advanced Planning



LCA Decision Context Classification (EU, 2008)

Long-term	Situation B: Meso/ macro-level decision
Mid-term	Situation A: Micro-level decision-support
Short-term	Situation C: Accounting

The Supply Chain Planning Matrix (adapted from Fleischmann et al. in Stadtler et al, 2008)

IMPACT ASSESSMENT: Environmental and Social LCIA, no LCC LCIA (Swarr et al, 2011) FOCUS: Social

Type 1 Indicators Selection:
- Top-down;
- Bottom-up.

Classification:
Sub-category indicators are assigned to category inventory indicators, which in turn are classified by stakeholders/impacts

Linear normalization:
- the larger the better (xij/maxxij);
- the smaller the better (minxij/xij);
- Ideal value (PRP) comparison (min(xijm Xj0)/max (xij,xj0))

Characterization:
Multiple criteria analysis:
- Ranking & ranking;
- AHP and pairwise comparisons;
- MAVT & MAUT.
- Preference determination techniques:
  - Revealed: hedonic-price method;
  - Expressed: contingent valuation;
  - Expected: uncertain.

Company performance assessment:
Arithmetic aggregation of results per stakeholder/ impact

Supply chain assessment:
Arithmetic aggregation of company performances per stakeholder/ impacts

Situation A: Micro-level decision-support

Situation B: Meso/macro-level decision-support

Situation C: Accounting

Type 2 Indicators Selection → Areas of Protection (AoPs)

Social impact pathways

INTERPRETATION of LCA, LCC and S-LCA results depending on the goal of the LCSA and the area of application

- **Performance reference points** (PRPs) for environmental, economic and social performance.
- **Aggregation functions**:
  - Multiple-criteria or attributes;
  - Multi-objective optimization (Pareto optimization);
  - Multi-person decision-making (Theory of Social Choice).
- **Conflict and cooperation between decision-makers (Game Theory)**:
  - Cooperative and non-cooperative games;
  - Zero-sum and non-zero-sum games;
  - Symmetric and asymmetric games;
  - Other...

LCSA APPLICATION:

Micro-level DM:
- Product development & improvement;
- Company's sustainability performance improvement (eco-and socio-efficiency);
- Other...

Meso-level DM:
- Strategic planning;
- Public policy-making (municipalities, cities, sectors, etc.);
- Other…

Macro-level DM:
- Strategic planning;
- National/EU policy-making;
- Other...

Conclusion

The results from the analysis show that several methods and tools can be used to strengthen the implementation of LCSA and serve as a basis for the development of a robust LCSA methodology. When applying these methods or tools, the purpose should be to take advantage of their strengths and avoid or reduce the occurence of their weaknesses, when applied to the field of life cycle assessment.

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