Briefing Document: Review of ISO 14040

Subject: Review of ISO 14040: - Environmental management - Life cycle assessment - Principles and framework

life cycle assessment (LCA)

Compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle

Objectives of LCA

- To help identify ways to improve a product's environmental impact at different stages of its life cycle.

- To supports decision-making in planning strategies, setting priorities, or designing better products and processes.

- To choose the relevant environmental performance indicators and measurement methods.

- For marketing purposes: environmental claims or environmental product declarations.

Limitations of LCA

It relies on assumptions, imperfect models, and often incomplete or general data. It may not reflect local conditions or when and where impacts occur. Results should be used for general insights, not exact answers, and only compared if based on the same assumptions.

Principles of LCA

Life Cycle View: Assesses environmental impacts across all product stages to avoid burden shifting.

Environmental Focus: Concentrates on environmental aspects; social and economic factors are typically excluded.

Relative Approach: Uses a functional unit as a reference for all data and comparisons.

Iterative Process: Phases inform each other, improving consistency and completeness.

Transparency: Clear documentation is vital for understanding and interpreting results.

Comprehensive Scope: Considers all environmental, health, and resource impacts to assess trade-offs.

Scientific Basis: Relies on natural science, or other justified methods if needed.

LCA Phases

– the goal and scope definition – inventory analysis – impact assessment – interpretation.

Life Cycle Inventory (LCI) studies comprise the goal and scope definition, inventory analysis, and interpretation.

Features of LCA

Full Life Cycle Coverage: Evaluates environmental impacts from raw materials to disposal, based on the defined goal and scope.

Relative and Flexible: Centered on a functional unit; level of detail varies with purpose.

Confidentiality: Accommodates proprietary information when needed.

Evolving Method: Open to updates as science and methods improve.

Comparative Use Rules: Special rules apply when results are made public.

No One-Size-Fits-All: Organizations can tailor LCA to their needs within standard guidelines.

Distinct Approach: Unlike other tools, LCA is system-based and relative, though it may use their data.

Potential Impacts Only: Results are not precise predictions due to inherent uncertainties.

System-Wide Insight: LCIA connects data to impact categories for broader environmental understanding.

No Single Score: Results aren't reduced to one number, weighting involves subjective choices.

Interpretation Phase: Uses a structured, iterative process to derive conclusions and connect with other tools.

General concepts of product systems

LCA models the life cycle of a product as a product system defined by its function rather than just its final outputs. This system is broken down into unit processes, which are connected through flows of intermediate products, waste, and environmental exchanges. Each unit process has specific inputs—some directly used in the final product and others serving as ancillary inputs—and produces outputs including products and environmental emissions. Elementary flows, such as resource use and emissions to air, water, or land, represent the system's interaction with the environment and form the basis of the Life Cycle Inventory (LCI). The level of detail in modeling and the boundaries of each unit process depend on the specific goals of the LCA.

Methodological framework

Goal and scope definition

The **goal** of an LCA states the intended application, the reasons for carrying out the study, the intended audience, i.e. to whom the results of the study are intended to be communicated, and whether the results are intended to be used in comparative assertions intended to be disclosed to the public.

The **scope** includes the product system to be studied; the functions of the product system or, in the case of comparative studies, the systems; the functional unit; the system boundary; allocation procedures; impact categories selected and methodology of impact assessment, and subsequent interpretation to be used; data requirements; assumptions; limitations; initial data quality requirements; type of critical review, if any; type and format of the report required for the study.

Function, functional unit and reference flows

In LCA, a system can have multiple possible functions, and the ones selected depend on the goal and scope of the study. The functional unit quantifies these functions and serves as a reference point for all related inputs and outputs. This reference is essential to ensure that results are comparable, especially when evaluating different systems. To support this, the reference flow—meaning the amount of product needed to fulfill the function—must be identified for each system. For example, when comparing paper towels and air dryers for drying hands, the functional unit could be "one pair of hands dried." The reference flow would then be the average mass of paper or volume of hot air needed per use, forming the basis for compiling input and output data for each system.

System Boundary

In LCA, product systems are modeled to represent key elements of physical systems, with system boundaries defining which unit processes are included. Ideally, inputs and outputs at the boundary should be elementary flows, but minor inputs or outputs that do not affect the study's conclusions may be excluded. The decision on what to include depends on the study's goal and scope, intended application, audience, assumptions, data availability, cost, and cut-off criteria. These choices, along with the models and assumptions used, should be clearly described. The system boundary significantly affects the reliability of results and the ability to meet the study's objectives. When setting the boundary, all relevant life cycle stages should be considered, such as raw material acquisition, manufacturing, energy use, transportation, product use and maintenance, waste disposal, recycling, ancillary materials, capital equipment, and supporting operations like heating or lighting. System boundaries are often refined during the course of the study.

Life cycle inventory analysis (LCI)

Inventory analysis in LCA involves collecting and calculating data to quantify the relevant inputs and outputs of a product system. This process is iterative, meaning that as data is gathered and understanding of the system improves, additional data needs or limitations may emerge. These may lead to adjustments in data collection methods, and in some cases, may require revising the study's goal or scope to ensure it remains aligned with its intended purpose.

Data collection in LCA involves gathering information for each unit process within the system boundary, including energy and raw material inputs, ancillary and other physical inputs, outputs like products, co-products and waste, emissions to air, and discharges to water and soil. Other environmental aspects may also be included. Since data collection can be demanding, practical constraints should be acknowledged in the study scope and documented accordingly.

Once collected, data must be validated and linked to the relevant unit processes and the reference flow of the functional unit. This enables calculation of inventory results for each process and the overall product system. Calculating energy flows requires considering the types of fuels and electricity used, energy conversion and distribution efficiency, and all related inputs and outputs.

Because most industrial processes generate multiple outputs and often recycle materials, allocation procedures are necessary to fairly distribute inputs and emissions among products and to handle recycled flows appropriately.

Life cycle impact assessment (LCIA)

The impact assessment phase of LCA evaluates the significance of potential environmental impacts based on the inventory results. This involves linking the collected data to specific impact categories and indicators to better understand the environmental consequences. The LCIA phase also informs the interpretation phase and may lead to revisiting or adjusting the study's goal and scope if the initial objectives are not being met. Since choices made in selecting, modeling, and evaluating impact categories can introduce subjectivity, transparency is essential to ensure all assumptions are clearly documented and communicated.

Mandatory Elements of LCIA

→ Selection of impact categories, category indicators and characterization models

→ Classification (Assignment of LCI results)

→ Characterization (Calculation of category indicator results)

Optional Elements of LCIA

→ Normalization (Calculation of the Magnitude of Category indicator results relative to reference information)

→ Grouping

→ Weighting

Separating the LCIA phase into distinct elements is important because each element can be clearly defined and evaluated on its own. This separation allows the goal and scope of the LCA to address each part individually and supports detailed quality assessments of methods, assumptions, and decisions. It also enhances transparency, making procedures and value-based choices easier to review and report. The specific impacts assessed, the level of detail, and the methodologies applied are determined by the study's goal and scope.

Limitations of LCIA

The LCIA phase focuses only on the environmental issues defined in the goal and scope, so it does not provide a complete assessment of all possible impacts related to a product system. It may not always reveal clear differences between impact categories or among alternative systems. This can result from limitations in the characterization models, sensitivity or uncertainty analyses, and from constraints in the inventory phase—such as incomplete system boundaries, data cut-offs, or poor data quality due to uncertainties, allocation choices, or aggregation methods. Additionally, inventory data may not be fully appropriate or representative for each impact category. A major source of uncertainty is the lack of spatial and temporal detail in the inventory results, which affects how accurately they can be linked to environmental impacts. Furthermore, no universally accepted method exists for consistently connecting inventory data to specific environmental outcomes, and the models used for various impact categories are at different stages of development.

Life cycle interpretation

The interpretation phase of LCA brings together the findings from the inventory analysis and, if applicable, the impact assessment, to draw conclusions aligned with the study's goal and scope. It should explain limitations, provide recommendations, and present the results in a clear, consistent, and understandable way. Since LCIA results are based on a relative approach, they indicate potential environmental effects but do not predict actual impacts, exceedances, or risks. This phase may also involve revisiting the scope and data quality to ensure consistency with the study's objectives. The final findings should reflect the evaluation and support informed decision-making.

Reporting

Reporting is a crucial part of an LCA and should cover all phases of the study. The report must clearly present the results and conclusions, along with the data, methods, assumptions, and limitations. For studies that include the impact assessment and are shared with third parties, additional details must be provided—such as how the results relate to the inventory data, data quality, protected endpoints, selected impact categories, models used, and the resulting impact indicators. The report should emphasize that LCIA results are relative and do not predict actual impacts. Any value-based decisions made during the assessment, such as choices in modeling, normalization, or weighting, must also be disclosed. If the study supports public comparative claims, it must follow ISO 14044 requirements, ensuring full transparency around judgments and rationales.

Critical review

Critical review in LCA is used to check whether the study follows proper methodology, uses appropriate data, and provides consistent interpretation and reporting. It ensures alignment with core LCA principles, though it doesn't judge the chosen goals or how the results are used. Critical review enhances credibility and understanding, especially when results are used for public comparisons. However, it doesn't imply endorsement of such comparisons. The review process is defined in the scope phase and must clarify its purpose, depth, and participants. Reviews can be done by internal or external experts with relevant expertise, or by a panel led by an independent chairperson and may include stakeholders like regulators, NGOs, or industry representatives. Confidentiality may be required depending on the content.