The Normative Framework for Eco-Design of Products: A Life-Cycle-Based Approach

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Abstract:

Eco-design is a strategic approach that makes it possible to reduce environmental impacts throughout the entire life cycle of products. This topic is highly relevant, as it responds to new environmental performance criteria and also addresses several major issues such as ecological transition, the circular economy, environmental protection, and industrial competitiveness.

The objective of this article is to define the standards that allow the establishment of requirements for product eco-design.

This study confirmed that the normative framework of eco-design produces significant environmental effects and outcomes.

Mots clés:
Éco-conception;
Analyse du cycle de vie;
Normes ISO;
Évaluation environnementale;
Management environnemental.

Codes de classification JEL:Q51, Q55, Q56.

Résumé

L'éco-conception est une approche stratégique qui permet de réduire les impacts environnementaux tout au long du cycle de vie des produits. Ce sujet est hautement pertinent, car il répond à de nouveaux critères de performance environnementale et traite également plusieurs enjeux majeurs tels que la transition écologique, l'économie circulaire, la protection de l'environnement et la compétitivité industrielle.

L'objectif de cet article est de définir les normes permettant d'établir des exigences pour l'éco-conception des produits.

Cette étude a confirmé que le cadre normatif de l'éco-conception produit des effets et des résultats environnementaux significatifs.

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1- The introduction:

In light of the escalating environmental issues faced globally, stemming from the excessive use of natural resources and rising pollution levels, it has become imperative to implement contemporary strategies that incorporate environmental considerations into the numerous industrial activities of organizations, particularly in product design. Eco-design represents one of the most crucial strategies in this domain, as it seeks to mitigate the environmental footprint of a product throughout its entire life cycle, encompassing everything from the extraction of raw materials to its eventual disposal.

Within this framework, international standards have surfaced as a valuable mechanism for governing environmental practices across enterprises. These standards offer directives for the incorporation of environmental factors into the design and development processes of products and services. They aim to foster a novel perspective grounded in life cycle analysis, thus aiding in the enhancement of environmental performance and facilitating a balance between economic and ecological dimensions.

The study of the relationship between environmental design, products, and ISO requirements therefore assumes considerable importance, particularly in a context in which industrial enterprises strive to achieve sustainable development and strengthen their competitiveness in markets.

Within this framework, the problem statement of this research revolves around the following main question:

How is product eco-design normatively framed in order to improve the environmental performance of enterprises?

From this central question, several secondary questions arise, namely:

- How are environmental considerations integrated into the product life cycle?
- What tools do enterprises use to apply eco-design principles?
- What are the main standards that frame product eco-design?

Study Hypotheses:

To address the research problem and the subsidiary questions, two hypotheses are formulated:

- Hypothesis 1: Effective eco-design is based on an assessment of impacts across all phases of the product life cycle.
- Hypothesis 2: The normative framework governing product eco-design systematically reduces environmental impacts.

Study Importance:

The importance of the study is reflected in the following points:

- Consideration of the necessity of integrating the environmental dimension into the various activities of the enterprise.
- The importance and role of product eco-design in reducing environmental impact and protecting the environment.
- The contribution of the international standard ISO 14062 to improving corporate environmental practices.

Study Objectives:

This study aims to:

- Analyze the concept of product eco-design.
- Analyze the normative framework governing product eco-design and define its modalities of application.
- Evaluate the role of eco-design in reducing environmental impact throughout the product life cycle.
- Formulate practical recommendations to improve the adoption of product eco-design within enterprises.

2- Environmental Assessment of a Product: A Necessity for Eco-Design:

Products may give rise to exchanges with the environment known as "environmental aspects," such as pollutant emissions generated and resources consumed. The outcomes of these interactions are evident in numerous ecological repercussions, including pollution of the atmosphere, hydrosphere, and lithosphere, alongside alterations in climate patterns.

To assess the environmental impacts of a product, an environmental evaluation is conducted. This constitutes a crucial and indispensable step in an eco-design approach. It enables the enterprise to (Thomas & Perdreau, 2015, p. 07):

- Understand the environmental profile of one of its products and identify the major issues.
- Determine the objectives of the eco-design approach in terms of reducing environmental impacts.
- Complement its design process through the integration of environmental criteria.

Standards established by AFNOR in 2013, along with eco-design directives, advocate for the implementation of multi-criteria environmental evaluations and life-cycle strategies for products. Such methodologies necessitate the incorporation of a broader range of activities and all materials involved, including those emitted, at each stage of the product's life cycle. Subsequently, this multi-criteria framework undergoes analysis to (Bris, Serhan, & al., 2019, p. 74):

- Determine the actions, frameworks, or materials that require alteration in order to enhance the ecological effectiveness of the system targeted for eco-design;
- Assess the real environmental effects of innovative solutions to ensure that the suggested modifications do not result in impact transfers across different life-cycle stages and among various environmental consequences.

This enables the company to make optimal design choices from an environmental perspective and thereby minimize the product's environmental impact.

Environmental assessment also supports the establishment of credible communication regarding an eco-designed product. By conducting this assessment, the company possesses data that it can use to provide accurate claims based on relevant indicators. To carry out this essential stage in an eco-design project, the company can rely on numerous tools ranging from the simplest negative lists to the most comprehensive life-cycle assessment.

3- Eco-design of Products:

3.1- Definitions:

Eco-design refers to the measures taken and activities undertaken following the integration of environmental performance criteria into a product development project (Vernier, 2024, p. 38).

Eco-design denotes a sustainable design approach that involves developing products, services, and systems with low environmental impact throughout their life cycle (Venkatesh, Rehman Khan, & Appadoo, 2025, p. 70).

3.2- The Global Approach to Eco-Design:

Eco-design is characterized by a multi-stage, multi-criteria, and multi-actor approach(De Bodard, 2015, p. 05).

- Eco-design constitutes an all-encompassing, multi-stage framework: It includes the various phases of the product life cycle, such as the extraction of raw materials, production, distribution, consumption, and end-of-life disposal.
- Eco-design is defined as a complex strategy: It encompasses considerations regarding material and energy consumption, emissions into natural environments, and consequences for the climate.
- Eco-design is acknowledged as a cooperative methodology: While the execution of eco-design is typically undertaken by a corporation or organization, its success requires the active participation of all pertinent stakeholders. Suppliers, recyclers, repair technicians, and recovery operators are essential participants in the product life cycle,

in addition to consumers, buyers, or users who influence the consumption phase.

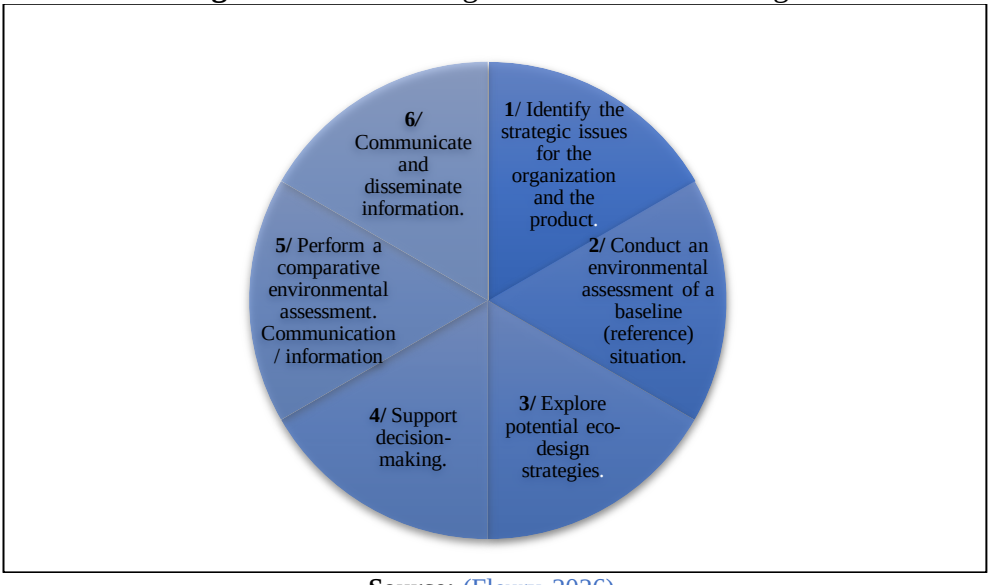
The aim of eco-design is to reduce adverse environmental effectsduring the entire life cycle of a product, all the whilepreserving or enhancingitsusability (Charlot-Valdieu & Outrequin, 2006, p. 34).

The justifications for an organization to incorporateeco-design intoits design and developmentproceduresencompass :(International Organization for Standardization (ISO), 2020, p. 07):

- Growing concern regarding environmental degradation, for example, climate change, resource depletion, biodiversity loss, and pollution;
- Identification of commercial prospects associated with resource efficiency and the circular economy, such as initiatives focused on minimizing carbon emissions and water consumption, alongside approaches for prolonging product lifespan, which encompass reuse, repair, refurbishment, and remanufacturing;
- Adoption of life cycle perspectives, which aids in recognizing environmental demands pertaining to a product, articulated by customers and other relevant stakeholders, both internal and external, as well as in averting inadvertent transference of environmental impacts throughout the product's life cycle.

4- The Stages of Product Eco-Design:

Figure No 1: The Stages of Product Eco-Design



Source: (Fleury, 2026).

According to the figure above, eco-design encompasses several stages (Gerard, Ramousse, & Boileau, 2025, p. 89):

- **Stage 1:** Framing the eco-design approach: This stage enables the identification of issues for the company and its products in order to define the eco-designed product most suited to the context. Several questions must be addressed: What scope should be given to the project? Which product will be eco-designed? What need does it fulfill for the customer?
- **Stage 2:** Environmental assessment of the reference situation: The initial environmental assessment identifies the environmental issues of the selected product from a life cycle perspective. It serves as the basis for defining the product's environmental strategy and for measuring the environmental performance of the new solution.
- **Stage 3:** Identification of eco-design opportunities: The framing stage and the initial environmental assessment make it possible to identify the project objectives and the problems to be addressed. The identification of eco-design opportunities therefore constitutes the idea generation and creativity phase (Fleury, 2026): selection of materials, manufacturing techniques, distribution, use, lifespan and end of life, and functions.
- **Stage 4:** Decision support: Decision support is the stage during which eco-design options are prioritized using structured and formal arguments in order to validate design choices.
- **Stage 5:** Comparative environmental assessment: This involves a comparative analysis to ensure that the new product has a lower environmental impact than the initial product. The reference situation identified in Stage 1 is compared with the final solution. This comparative analysis verifies that no transfer of environmental impact has occurred and that the new solution is indeed more environmentally beneficial.
- **Stage 6:** Environmental communication: Once the product is available on the market, the company can proceed with communication. This stage highlights the company's environmental approach regarding its offering, both internally and externally. The objective is to capitalize on this experience through a marketing and commercial approach.

In the context of eco-design for a product or service, implementing the 4R strategy is essential for minimizing environmental effects. The 4R framework represents a fundamental aspect of the circular economy, encompassing the principles of Reduce, Reuse, Recycle, and Repair.

5- Checklist of Actions Applicable in Product Eco-Design:

In order to improve the environmental impact of products and services, various areas of action are considered and presented in the table below (Aurez & Georgeault, 2019, p. 88).

Table No 1: Eco-Design Checklist

Axes	Items
Selection of low-impact materials and assemblies	- Use productscontainingrecycledmaterials. - Use productsthat are easily recyclable. - Control risksassociatedwithmaterials and substances, includingreducing the use of toxicmaterials. - Use renewable and replenishedmaterialsthat are biodegradable and present no toxicologicalrisk. - Reduce the mass and material volume of the product or its components.
Production methods	- Prioritizecleaneroperations. - Minimizemanufacturingsteps. - Limit energyconsumption. - Limit the use of water-intensive processes. - Reducewastegeneration. - Limit impacts on production sites such as emissions and wastewater.
Logistics and packaging	- Reduce at the source, includingmaterial use and volume. - Favorcombined transport and appropriate fuel choices. - Optimizeloading.
Product use	- Improvequalitythroughreduced nuisances, decreasedwaste, and resourcesavings. - Use productsthat are more energy-efficient or thatrely on renewableenergy.
Durability and reliabilitystrategy	- Optimize service life. - Facilitateservicing and maintenance. - Facilitatedisassemblysuch as through the availability of spare parts. - Identifymaterials to enable subsequentrecycling. - Promote new uses and additionalfunctionalities. - Enhance end-of-life value throughenergyrecovery, recycling, and new applications.

Source: (Aurez & Georgeault, 2019, p. 88).

6- The Four Levels of Product Eco-Design:

Eco-design is a continuous improvement approach. A product is eco-designed in relation to another product and in connection with a specific context and strategy. It is therefore essential to question the relevance of the choices made and to implement new actions aimed at reducing environmental impact.

At each iteration, eco-design makes it possible to challenge knowledge about the enterprise and the product to varying degrees, with the objective of developing a product that has progressively lower environmental impact while remaining relevant in the market.

Four levels of eco-design are identified according to the concrete outcome of the approach applied to a product. These levels are permeable.

They primarily serve as a reference framework for the degree of enterprise commitment and the extent to which the product or project is reconsidered. This varies from one level to another and entails different implications within the enterprise (Eco-design Center, 2023).
These four levels are presented in the figure below:

Figure NO 2: The Four Levels of Product Eco-Design

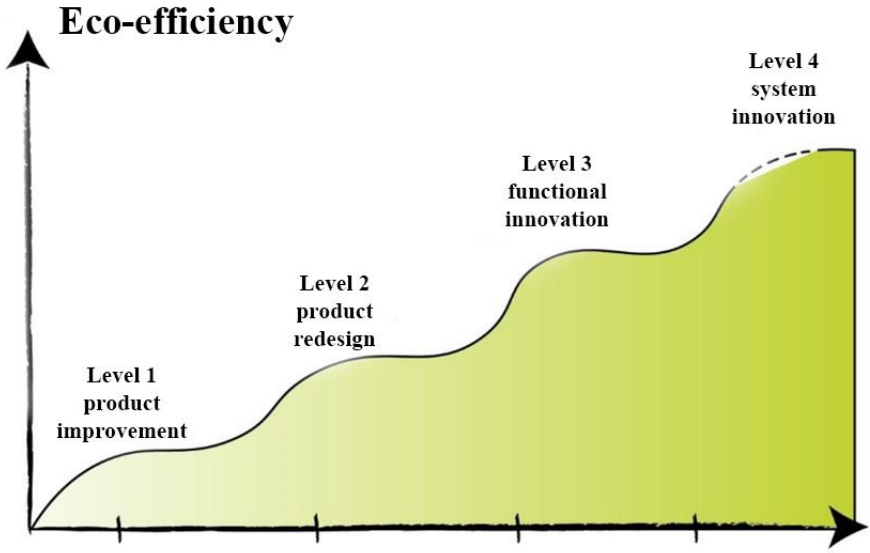


Diagram of the four levels of eco-design

Source: (Dal Pont, 2025, p. 74).

- **Level 1: Product Improvement**: This level involves improving life cycle characteristics that slightly reduce environmental impact through changes that are easy for the company to implement, such as updating performance, material optimization, waste management, etc.
- **Level 2: Product Redesign**: Redesign goes further. A reflection entirely dedicated to eco design makes it possible to question each decision and each element of the product throughout its life cycle, while preserving the product's function and its response to the actual need. The product is thus reconsidered in a comprehensive manner, and environmental gains can be significant.
- **Level 3: Innovation in Function:** Level 3 begins to address eco innovation and responds to the following question: how can a product delivering the same function be produced differently, in a disruptive way, allowing the reduction of environmental impact? This often involves the implementation of disruptive technology requiring major changes throughout the entire value chain and raising questions regarding customer acceptability.

- **Level 4: Innovation in the Value Creation System:** This level questions the function fulfilled by the company when placing the product on the market: how can this function be delivered differently by reconsidering the created value and the entire surrounding business model? This level of eco design connects with the functional economy, which proposes high value-added services rather than product sales.

7- Eco design tools:

Several eco design methods have been identified in industry and are presented in the following table:

Table NO 2: Eco design tools

Tool	Description of the Tool
Multicriteria life cycle analysis	Consideration of all stages of production, from the use of raw materials to the end of the product's life, corresponding to an analysis of inputs and outputs within the production chain.
Single criterion life cycle analysis	Examples include product carbon footprint and water footprint.
Matrix approach	Analysis of impacts using a two-dimensional table, the first indicating the stages of the life cycle and the second the environmental impacts.
Environmental effects analysis	Technique derived from the quality management system, functioning similarly to failure modes and effects analysis.
Qualitative approach	Simplified and qualitative evaluation of the life cycle, consisting of improving the existing product. Based on the principle of benchmarking.
Integrated approach or environmental impact assessment	The execution of a strategy for ongoing enhancement that prioritizes the assessment of ecological effects, diminishes environmental hazards, safeguards public health, conserves natural assets, maintains air and water quality, and curtails waste generation..
Guideline	In depth analysis of impacts through the selection of strict stages within product development processes or the life cycle.
List of substances	Regulation indicating substances subject to authorization and restriction.
Checklists	List of questions to guide eco design strategies such as the eco design strategy wheel.
Standards	General approach such as ISO 14006 standards, which provide guidelines for incorporating eco design.
Others	Ecological backpack seeking balance between inputs and outputs using life cycle analysis, financial approach involving life cycle cost analyses, total costs, externalities, and life cycle management.

Source:(Vernier, 2023, p. 62).

The above table presents eleven available methods that allow the evaluation of environmental impact within an eco-design approach. Based on this, designers must choose the most appropriate tool, and the method most widely used in industry remains life cycle analysis.

8- The benefits of product eco design:

Adopting an eco-design approach offers benefits on different levels (Gendre, 2025):

8.1- Environmental benefits:

From an environmental perspective, eco design makes it possible to:

- Reduce the carbon footprint by favoring materials or processes that enable the company to lower its greenhouse gas emissions;
- Generate less waste by using recyclable components or packaging;

- Optimize resource use by identifying what is essential and what is superfluous and by learning to optimize the use of existing resources.

8.2- Economic benefits:

From an economic perspective, this approach makes it possible to:

- Reduce product related costs by eliminating unnecessary packaging or by adopting a more streamlined design;
- Boost sales by responding to consumers' eco responsible expectations.

8.3- Administrative benefits:

From an administrative perspective, eco design responds to a real need:

- To develop an offering that is more environmentally respectful and capable of withstanding uncertainties created by climate change. In this context, eco design is a way to:
- Anticipate future environmental regulations as well as potential risks;
- Claim compliance with environmental standards that are expected to become widespread;

7.4 Social benefits:

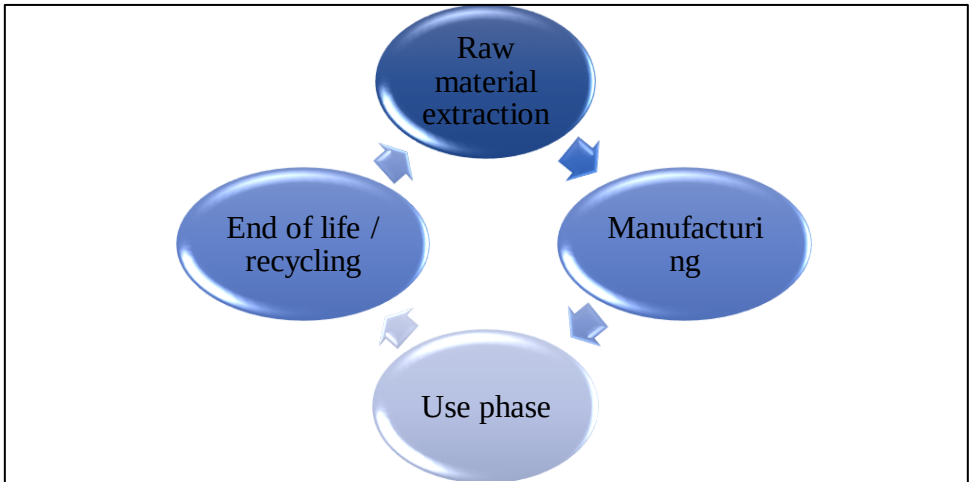
Prioritizing eco design may also generate social and societal benefits:

- By contributing to the minimization of environmental risks;
- By also minimizing health risks linked to the use of harmful materials and substances;
- By helping to stimulate the local economic fabric, for example by choosing nearby suppliers.

9- The product life cycle approach:

Life cycle assessment serves as a methodology for evaluating the environmental effects associated with a product, process, or service, encompassing the entire spectrum from the extraction of raw materials to the disposal upon completion of its useful life, while also factoring in the distribution and utilization stages. At each of these phases, there are interactions between products, processes, and the surrounding environment. The International Organization for the Environment and ISO 14040 articulate the life cycle analysis framework as follows: "Compilation and evaluation of the inputs and outputs, as well as the potential environmental impacts of a product system throughout its life cycle" (Belkhir, Louhab, & al., 2022, p. 06). Eco-design is predicated on the life cycle approach, which mandates that the significant environmental considerations of a product are taken into account during the design phase, encompassing all stages of its life cycle, as illustrated in the subsequent figure (Duquet, 2025, p. 20).

Figure No 3: Product life cycle



Source: (Duquet, 2025, p. 21).

The eco-design methodology facilitates the identification of the stages within the product life cycle that exert the most significant environmental influence. Consequently, interventions can be implemented at various points throughout the life cycle (De Bodard, 2015, p. 34) (De Bodard, 2015, p. 34). The table below elucidates the incorporation of eco-design across the distinct phases of the life cycle:

Table No 3. Integration of eco-design into the different stages of the life cycle

Product life cycle phase	Possible actions
Raw material extraction or production	– Work with suppliers to select the most environmentally friendly raw materials. – Evaluate the cost benefit for the company.
Manufacturing	– Optimize production techniques by reducing requirements for raw materials, energy, and water. – Optimize packaging such as packaging type, volume, and weight.
Distribution	– Seek the least polluting means of transport. – Optimize logistics.
Consumer use	– Increase product lifespan through reparability and availability of spare parts. – Reduce product or service impacts during use, such as saving water, reducing waste, and lowering energy consumption.
End of product life	– Use recyclable materials. – Facilitate the separation of product components during sorting.

Source: (De Bodard, 2015, p. 34).

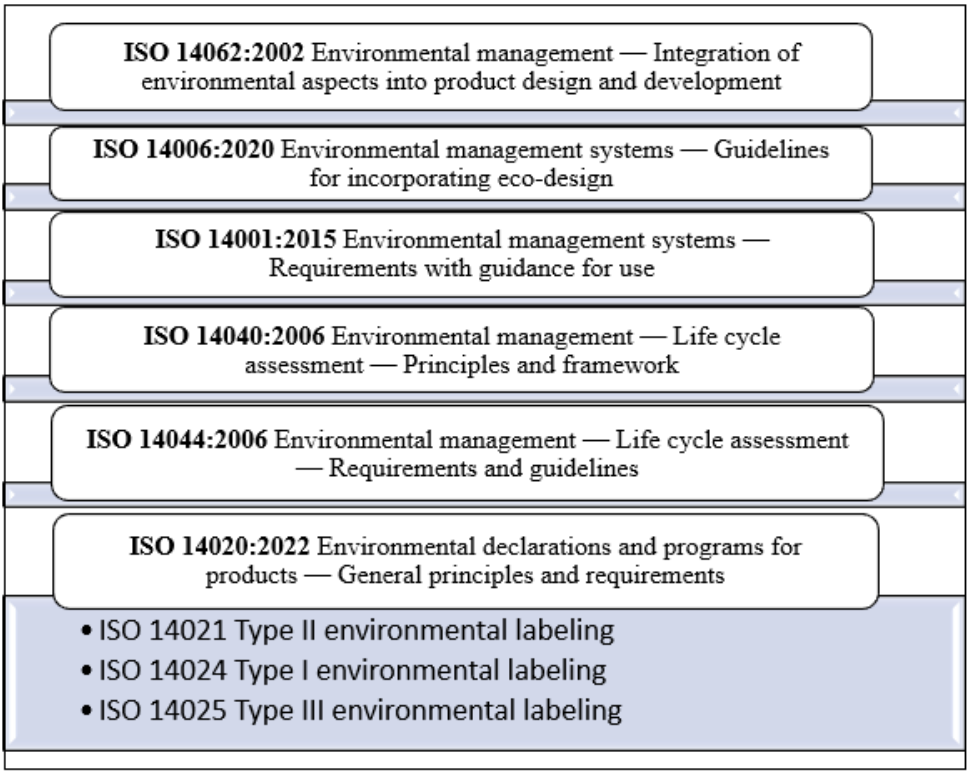
10- Standardization and environmental declarations:

10.1- ISO standards:

The International Organization for Standardization (ISO) has established a set of guidelines for environmental management, referred to as the ISO 14000 series. Certain standards within this series specifically pertain to ecological design. Their aim is to promote the alignment of business and environmental goals by urging the incorporation of environmental factors into product development. The ISO 14000 standards encompass various domains, including the assessment of environmental performance, environmental labeling, life cycle analysis of products, and other environmental considerations.

Several standards frame the implementation of an eco-design approach: (www.iso.org) as shown in the following figure:

Figure No 4: ISO standards for the product eco design approach**.**



Source: developed by the researcher based on the website(ISO).

10.1.1- The first standard governing the eco-design approach ISO 14062:2002

The concepts of eco-design were established at the international level in 2002 with the publication of the ISO/TR 14062 standard (Morana, 2018, p. 62).

This standard delineatescontemporary notions and methodologiesconcerning the incorporation of environmental factorsinto the design and development of products, where the term "product" refers to bothphysical items and services (ISO). ISO 14062:2002 offers a framework for eco-design thatencompasses the following stages (Acsio Energie, 2023):

- Identify environmental aspects throughout the product life cycle;
- Assess the environmental impacts of the product;
- Define environmental objectives for the product;
- Design the product using eco-design methods and tools;
- Analyze the environmental performance of the product and compare it with its environmental objectives;
- Improve product design using the results of the environmental performance assessment.

10.1.2- ISO 14006:2020

"Environmental management frameworks - Recommendations for integrating ecological design ", published in October 2011, provides guidance for implementing, maintaining, and improving eco-design management. Revised in 2020, these standard structures the integration of eco-design into an environmental management system.

10.2- Other complementary standards related to eco-design

10.2.1- ISO 14001:2015

This guideline articulates fundamental tenets for integrating ecological factors within commercial activities, including product development. This international standard aids enterprises in achieving the intended objectives of their environmental management frameworks, which yield supplementary benefits for the ecosystem, the entity itself, and its stakeholders. In alignment with the organization’s environmental policy, the expected results of an environmental management system are comprised of:

- Enhancement of environmental performance;
- Satisfaction of compliance requirements;
- Realization of environmental goals.

10.2.2- ISO 14040:2006

"Environmental management - Life cycle assessment - Principles and framework" serves as a key methodological reference. It provides a structured framework for conducting a rigorous Life Cycle Assessment from raw material extraction to the end of life of a product or service(ISO).

10.2.3- ISO 14044:2006

These standard details the associated technical and methodological requirements, including(ISO):

- Establishment of the objectives and boundaries of the life cycle assessment investigation;
- The phase of life cycle inventory;
- The phase of life cycle impact evaluation;
- The phase of life cycle interpretation;
- Dissemination and critical examination of the life cycle assessment;
- Constraints associated with the life cycle assessment;
- Interconnections among the phases of the life cycle assessment;
- Prerequisites for the application of value judgments and optional components.

These two standards are therefore complementary:

- ISO 14040:2006: strategic vision and framework.
- ISO 14044:2006: operational implementation.

10.2.4- ISO 14020:2022 series

This series governs commercial communication concerning claims about the environmental performance of products. It includes ISO 14021 for self-declared claims, ISO 14024 for labels, and ISO 14025 for environmental product declarations.

10.3- Environmental Declarations:

When a company undertakes an eco-design approach, it is beneficial to seek commercial advantage by communicating about products that are more environmentally friendly.

Three forms of environmental declarations are governed by the ISO 14020 family of standards, which addresses environmental labeling of products, including communication on the environmental aspects of products and services (Faure, p. 25).

- Third-party ecolabels (Type I environmental labeling, ISO 14024) highlight products that comply with environmental requirements defined in specifications for each product category and that fulfill the same function. They address ecological impacts across the entire life cycle of a product. The reference frameworks for these ecolabels are developed through consultation among stakeholders.

  Thus, environmental logos identify products and services that are committed to limiting their environmental impacts. Environmental logos provide technical criteria for product improvement. They are based on specifications and may be used as guides for eco-design.
- Self-declared environmental claims: These environmental claims are made under the sole responsibility of the producer. This corresponds to Type II environmental labeling (ISO 14021). A self-declaration

generally concerns only a single environmental characteristic of the product, such as recyclability or degradability. Self-declarations are not subject to third-party verification.

- Ecoprofiles: This corresponds to Type III environmental labeling (ISO 14025). An ecoprofile consists of communicating the environmental performance of a product. It is not merely a claim, as it involves providing quantitative data on the environmental impacts of the product. It represents a presentation of the results of the product life cycle assessment. An ecoprofile may be updated by the manufacturer to demonstrate environmental improvements of the product.

11- Conclusion:

Eco-design is a proactive and strategic approach that enables companies to reconcile economic performance with environmental responsibility. By integrating environmental considerations from the product design stage, it promotes innovation, competitiveness, and sustainability. It constitutes an essential lever for addressing current and future challenges of sustainable development.

Consequently, eco-design is grounded in a holistic methodology that incorporates the evaluation of environmental effects at every phase of the product lifecycle, in alignment with the ISO 14062 standards and life cycle assessment principles. The regulatory framework of eco-design plays a crucial role in minimizing environmental impacts by facilitating the incorporation of ecological considerations from the initial design stage and throughout the full product lifecycle.

Finally, eco-design remains a promising tool and an essential pillar for building sustainable institutions capable of meeting future challenges.

Study Findings:

- Product eco-design is becoming a strategic axis in the overall corporate policy.
- The normative framework plays a fundamental role in implementing eco-design practices within companies.
- Environmental regulations enable the identification and examination of crucial stages in the product life cycle regarding their ecological effects.
- The adoption of environmental standards in eco-design positively influences the integration of environmental aspects into the product design process.
- The adoption of eco-design standards contributes to improving environmental performance.

Study Recommendations:

- Every company should integrate life cycle assessment from the design phase.
- Strengthen training and awareness of human resources in order to master normative and regulatory tools.
- Establish regulatory and economic incentives to encourage companies to adopt eco-design practices for products.
- Encourage companies to obtain environmental certifications through the development of incentive-based public policies (subsidies, tax benefits…).

- The integration of environmental standards is essential to improve environmental performance.
- Establish an internal audit system to ensure compliance with eco-design and environmental management standards.
- The environmental dimension should be integrated into the culture of every company.

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