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Eco-efficiency



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competitive price, satisfying human urgencies and ensuring the quality of life while reducing ecological impacts and resource exploitation throughout the life cycle to a degree at least in line with the carrying capacity of the Earth (WBCSD 2000).

Synonyms

[Ecological efficiency](#); [Environmental efficiency](#)

Definition

The term eco-efficiency originates from the fusion of two words, the noun “efficiency” and the adjective “ecological.” It was created in 1992 by the World Business Council for Sustainable Development and quoted in the publication “Changing Course” (Schmidheiny and Timberlake 1992).

It refers to the managerial attitude that aims at decreasing ecological damage while increasing the efficiency of the production processes; minimizing the use of energy, material, and water; recycling more by-products; and eliminating hazardous emissions or wastes.

The notion was publicized by the BCSD (Business Council for Sustainable Development) in 1992 during the World Conference on Environment and Development in Brazil and consists of offering goods and services at a

Historical Development of the Concept

The impact of anthropic activities on the environment was first studied, during the 1970s, by Ehrlich and Holdren (1971), considered the founders of the ecological economics research field, which formalized the following equation:

$$Impact = f(Population, Affluence, Technology)$$

Before the abovementioned publication “Changing Course,” the notion of eco-efficiency was developed by McIntyre and Thornton (1978), but the term was formally created and explicated by Schmidheiny and Timberlake (1992). He asked for a change in the perception as a key part of the solution for stopping environmental degradation and achieving global sustainable development (Ehrenfeld 2005; WBCSD 2000).

Thanks to some forward-looking managers and thinkers, eco-efficiency evolved from an idea to a concrete, experimental, and applicable theory, culminating in the publication of the Environmental Performance and Shareholder Value report (Blumberg et al. 1997).

Von Weiszäcker et al. (1998), in the book titled *Factor Four*, reformulated the concept of efficiency and proposed a meaning of the term eco-efficiency. In their publication, efficiency is intended as something which enables the well-being of humanity to be separated from the consumption of resources. According to the authors, improving and calibrating efficiency, through a series of techniques and methodologies already available, it is possible to quickly reach a more rational use of resources, achieving environmental, social, and economic benefits.

Starting from the concept of efficiency, which, according to the ISO 9241 standard, indicates the accuracy and completeness of the objectives achieved in relation to the resources spent, the adjective ecological characterizes the abovementioned objectives, ascribing them to the field of complex interactions and equilibria between living organisms and the surrounding environmental conditions, generated by natural abiotic and biotic components and by factors present in that particular environment.

The concept of eco-efficiency therefore indicates the ability of an organization to achieve the goals of construction, production, and supply of commodities and services using fewer and fewer resources and generating less and less waste and pollution. To understand the degree of eco-efficiency of a given ecosystem, the consideration of three factors is relevant:

- The material, energy, and information flow that is determined in that context
- The interdependence of the organisms that live in that context
- The effectiveness of the material and immaterial flows taking place between the various levels of the ecosystem organization

According to the WBCSD, the strategies to achieve eco-efficiency consist in, on the one hand, reducing the dispersion of toxic materials and waste in general and, on the other hand, increasing the recyclability of materials and waste, the use of renewable resources, and the

duration of components (WBCSD 2000; Lovins 2012).

Eco-efficiency Assessment

Considering the current economic turbulences, the environmental challenges and pressures for a more sustainable world, the new international standard UNI EN ISO 14045 named “Environmental management – Eco-efficiency assessment of product systems – Principles, requirements and guidelines” holds enormous and global potential.

The rule describes the principles, requirements, and guidelines for the eco-efficiency evaluation of a product system. The key objectives are:

- To establish a clear terminology and a common methodological framework for the evaluation of eco-efficiency
- To provide precise guidelines on the interpretation of the results of these assessments
- To encourage transparent and precise communication of the results

Eco-efficiency is a factor of sustainability that links the environmental performance of a product’s life cycle to its value. In a world characterized by some full developing countries, the eco-efficiency assessment represents a management tool necessary to decrease the overall environmental impact.

Eco-efficiency is increasingly becoming an essential requisite for the success of companies. By applying ISO 14045, the user will be able to simultaneously manage the characteristics of environmental, commercial, and economic sustainability of their products and product systems.

The evaluation of eco-efficiency aims at optimizing the performance value of the product system on different levels, i.e., its raw materials, production, delivery, efficiency of use, or a mix of these. Value can be expressed in financial terms or in other forms, with one and the same result: doing more with less.

The steps of eco-efficiency evaluation of a product system include:

- The definition of the objective and the field of application of the assessment
- The environmental impact assessment
- The evaluation of the product system value
- The measurement of eco-efficiency
- The explanation of results (including the quality control of the evaluation)
- The reporting
- The critical review of the eco-efficiency estimation

Eco-efficiency can be considered realized by achieving the increase of the product or service value, the resource efficiency optimization, and the environmental impact reduction.

Eco-efficiency Measurement

The abovementioned definition by the WBCSD states that eco-efficiency is achievable if goods and services are produced at competitive prices meeting human urgencies and bringing quality of life by gradually decreasing the environmental impacts of products and resource exploitation during the whole life cycle management. Considering this definition, eco-efficiency accounting, aimed at the assessment phase, can be conducted through two main classes of measurement:

- Environmental productivity and its reciprocal, i.e., the environmental intensity of production
- The cost of environmental progress and its reciprocal, i.e., the environmental cost-effectiveness

Each of the indicators comprised in the two classes of measurement can be calculated for any unit conducting economic activities. This is possible because the latter always refer to cost and value, but also have a physical connotation, and thus unavoidably affect the environment (WBCSD 2000; Huppés and Ishikawa 2009).

The eco-efficiency indicators, mainly represented by ratios, can also be applied to a macro- or micro-level. The determination of the calculation methodology of eco-efficiency indicators at a micro-level can be conducted through the incremental eco-efficiency method, the win-win method, and the difference eco-efficiency method.

The first expresses the effects of the total value of a product system or alternatively its total connected environmental effects. The second method compares a historical reference situation, used as a benchmark, with new potential scenarios based on the use of innovations (Huppés and Ishikawa 2009). The third method, in line with the second, makes a comparison exclusively between the two alternative innovations that potentially contribute mostly to the increase in eco-efficiency.

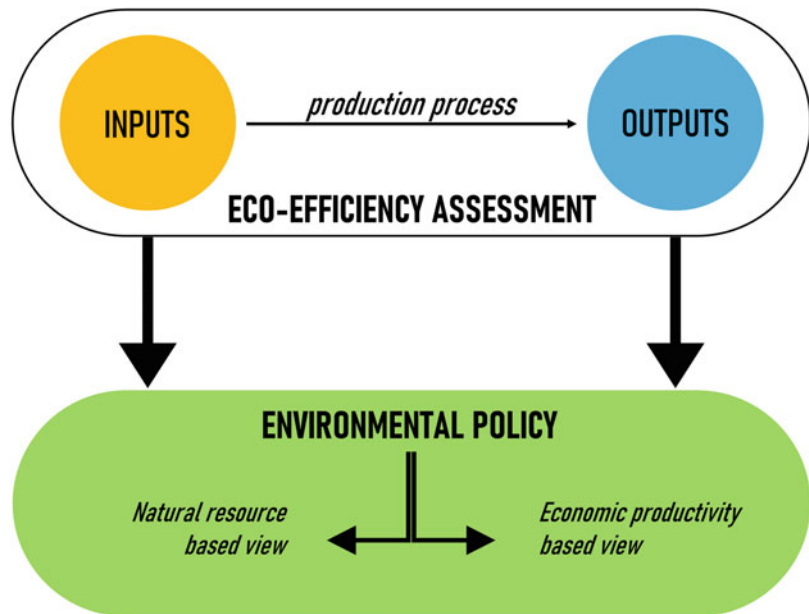
Since the ultimate goal of eco-efficiency assessment is to support the decision-making process toward optimality on a national/global scale (WBCSD 2000; Ruffing 2007; Huppés and Ishikawa 2009), scientific efforts are mainly addressed toward the improvement of macro-level measurements, which so far are less consistent and accurate (Ruffing 2007).

Policy Implications and Developments

Quantifying and evaluating eco-efficiency provides decision-makers with relevant information for drawing up policies addressed to sustainability, which, for example, consist in an expansion in environmental expenditure or a strengthening rule to avoid market failures. As shown in Fig. 1, assessing eco-efficiency through input- and output-oriented approaches support policymakers to evaluate if environmental policy should be addressed at minimizing input (natural resources savings) or maximizing output keeping constant input quantities (increased economic productivity) (Toma et al. 2016).

The policy strategies centered on the concept of eco-efficiency include Factor 4 and Factor 10 by WBCSD. Boulanger (2010) identified the key factors common to all eco-efficiency strategies, i.e., trust in technological innovation in

Eco-efficiency,
Fig. 1 From eco-efficiency
 assessment to
 environmental policy.
 (Source: Personal
 elaboration)



terms of sustainability; companies as main drivers of transformation; trust in markets; and positive perception of growth.

The improvement of eco-efficiency, as a driving force for sustainability, has been questioned by Huesemann and Huesemann (2011). However, the new cradle-to-cradle and sustainable production and consumption approaches, assuming changes in lifestyles and production models, imply a key responsibility of companies as they consume and produce. The notion, the assessment, and the accounting of eco-efficiency can be useful tools for companies to achieve sustainable development, integrating two of its three axes, the economic and the environmental ones (Ehrenfeld 2005), making it easier to address social issues later (WBCSD 2000).

Summary

The term eco-efficiency originates from the fusion of two words, the noun “efficiency” and the adjective “ecological,” coined in 1992 by the World Business Council for Sustainable Development. It refers to the managerial attitude that aims at decreasing ecological damage while increasing efficiency of the production processes;

minimizing the use of energy, material, and water; recycling more by-products; and eliminating hazardous emissions or wastes. Quantifying and evaluating eco-efficiency provides decision-makers with relevant information for drawing up policies addressed at sustainable development, which, for example, consists in an expansion in environmental expenditure or a strengthening rule to avoid market failures. The notion, the assessment, and the accounting of eco-efficiency can be useful tools for companies to achieve sustainable development, integrating two of its three axes, the economic and the environmental ones, making it easier to address social issues later.

Cross-References

- ▶ [Ecological Economics](#)
- ▶ [Efficiency](#)
- ▶ [Life Cycle Management](#)
- ▶ [Rebound Effect of Eco-efficiency](#)
- ▶ [Resource Efficiency](#)

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