

3 From thermodynamic efficiency to eco-efficiency

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Abstract

According to Webster's Revised Unabridged Dictionary, efficiency is (1) the quality of being efficient or producing an effect or effects and (2) (in the context of mechanics) the ratio of useful work to energy expended. The first description obviously relates to more everyday language than the more science-focussed second description. This second one, however, is restricted to mechanics and thermodynamics. The efficiency concept is also used in economics, but there it appears to indicate the state of optimality, and not a quantifiable degree of optimality.

There is as yet no unambiguous and generally accepted definition of eco-efficiency. Obviously, eco-efficiency is a term that has emerged from everyday, rather than scientific arguments. It is, however, equally obvious that eco-efficiency should in the course of time, and in its development into a quantifiable and communicable term, be further specified on a scientific basis. Admittedly, consensus seems to be growing that an eco-efficiency indicator expresses the ratio between an environmental and a financial variable, witness the various texts by Schaltegger, the WBCSD, the OECD and the UN. But there is still much confusion.

This paper argues that this confusion may be due to an unconventional use of the term 'efficiency'. In order to develop a better understanding of the exact meaning of eco-efficiency, it reviews the thermodynamic origins of the efficiency concept. This serves as a point of departure for a generalisation of this concept to a form that will accommodate eco-efficiency as well.

The interpretations of the term efficiency in the economic vocabulary are also reviewed in this context. I then present an axiomatic scheme for an efficiency indicator, on the basis of a ratio of input to output exergy. Its usefulness is illustrated by an example relating to iron production. Finally, the paper shows that the ‘economy–environment ratio’ – even though it is not an actual efficiency or eco-efficiency – is still a useful indicator. I propose to call this the ‘eco-productivity’.

3.1 Introduction

Within the last decade, the term eco-efficiency has become popular in the realm of industrial ecology, cleaner production and related fields dealing with questions of sustainability. One would expect that such a popular term would have a clearly defined, unambiguous and generally agreed meaning. This is, however, not the case. As I will show, eco-efficiency can refer to a target, it can refer to an indicator, or it can refer to a tool. Quantitative indicators of eco-efficiency can differ in terms of meaning and/or units. As Schaltegger & Burritt (2000, p 49) remark:

In practice, the term has been given different meanings and, as a result, has little precision.

This situation is clearly not conducive to the acceptance of sustainability as a field of scientific progress, while appropriate and universally accepted definitions of concepts such as eco-efficiency may well gain greater respect for the field.

In this paper, I explore some of the fields of study in which the term efficiency is used. From the overview thus obtained, I draw some conclusions as to the universal properties of the efficiency concept. This will enable me to provide a less ambiguous and more consistent definition of eco-efficiency.

3.2 The efficiency concept and term as used in a variety of fields

This section explores some of the places where the term efficiency shows up. I start with its use in everyday language, and end up in economics and statistics.