Resource Efficiency – what are the Objectives?

Marko Gernuks[1]

[1] Volkswagen AG, Group Research Environmental Affairs Product; Wolfsburg, Germany

Abstract

This paper shows that resource efficiency pursues the three objectives *reducing environmental impacts, improving supply security* and *saving costs*. Firstly, a differentiation is established between objectives and measures to achieve them. Secondly, methods to assess improvements relating to these objectives are discussed and applied to the case study of vehicle lightweight design. The presented example of substitution of steel by aluminum illustrates that trade-off between objectives may occur. Thus, a reliable assessment of measures to enhance resource efficiency must consider impacts on each objective separately. An aggregation to only one resource efficiency indicator lacks transparency and is not appropriate.

Keywords:

Resource Efficiency; Life Cycle Assessment; Methodology

1 INTRODUCTION

There is general agreement regarding the importance of resource efficiency, and almost every company can point to resource-efficient products. But more detailed discussion reveals that resource efficiency has many different meanings, which vary depending on the particular standpoint. In a range of presentations and publications, techniques such as substitution, recycling, lightweight design etc. are presented as resource-efficient, even though no commonly accepted definition of the term exists, as yet.

This paper does not intend to provide a definition of resource efficiency, but aims to clarify the objectives of resource efficiency. The term "resources" as used here refers to non-energetic raw materials.

Furthermore, the challenges of defining appropriate assessment indicators for resource efficiency are described and aspects that have to be taken into account are discussed.

2 OBJECTIVE OR MEASURE?

In the absence of general agreement on what resource efficiency really is, no differentiation has yet been established between resource efficiency objectives on the one hand and measures to achieve them on the other.

Taking recycling as an example, it is first necessary to ask the question – why recycle? Why is it desirable to strive for closed-loop material use? Essentially the assumption is that closed-loop recycling will have a reduced environmental impact compared to primary production. Cost savings are also expected, as well as enhanced resource supply security. It follows from this that recycling is a *measure* to achieve the *objectives:*

- reducing environmental impacts,
- improving resource supply security, including lowering import dependency, e.g. for metals, and
- cost savings in production.

Besides recycling, other potential measures to achieve the above-mentioned objectives include substitution, extended product lifetime or use of renewable raw materials. But none of these measures are objectives themselves, as it makes no sense to recycle material without reducing environmental impacts, improving supply security or saving costs.

Taking the proposed differentiation between objectives and measures as a basis, as a next step a framework for the assessment of resource efficiency can be developed. I.e. measures can be assessed with regard to their efficiency in achieving improvements with regard to the three objectives.

The following sections discuss challenges with regard to the respective assessment procedures and provide proposals as to how to tackle these.

3 ASSESSMENT OF ENVIRONMENTAL IMPACT

An important aspect in assessing environmental impacts is the definition of system boundaries. For raw materials often only the impact of the production phase is considered when performing such assessments. However, materials choices may significantly influence environmental impacts during the product use phase as well.

This can be demonstrated by the practical example of lightweight vehicle design (cf. Figure 1). The aim of the car manufacturers is to reduce vehicle weight in order to reduce fuel consumption and thus also CO_2 emissions. In this context the substitution of steel by the lightweight material aluminum is a promising measure. Depending on the specific vehicle part that is substituted by aluminum, a weight reduction of 10 to 40% compared to steel is possible [1]. At first sight, this might be thought to represent a big improvement in resource efficiency. Looking at the CO_2 emissions during production, however (Figure 1), it becomes clear that aluminum causes significantly higher CO_2 emissions than steel at this stage, even if the full lightweight design potential of 40% is realized. If the system boundaries were restricted to material production, steel would clearly be the preferable alternative to aluminum. However, a

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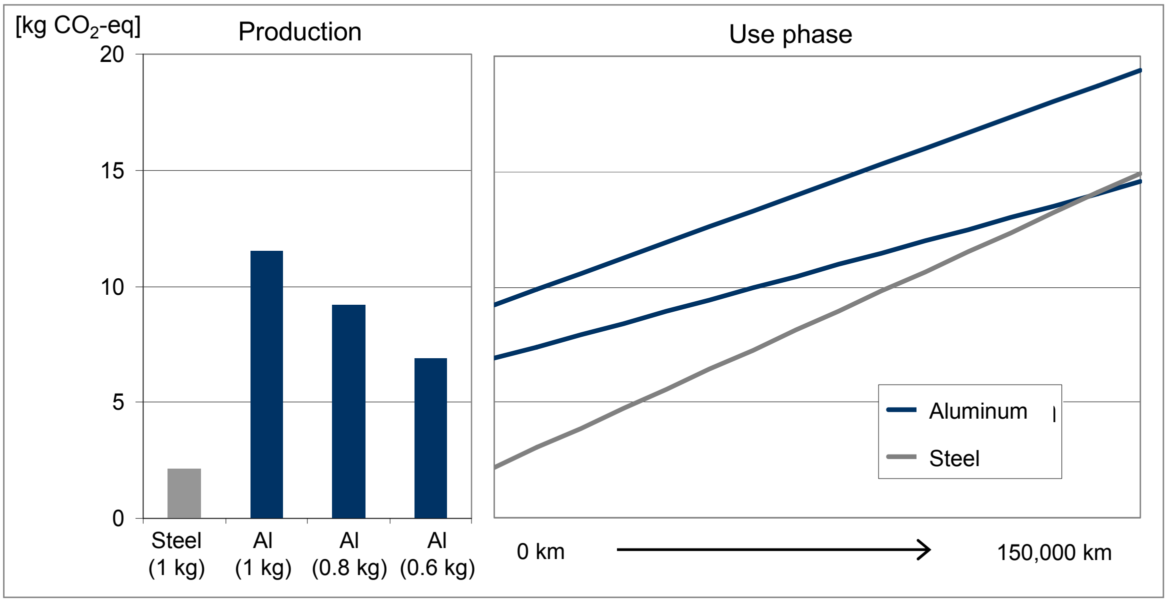

Figure 1: Greenhouse gas emissions of lightweight vehicle design based on replacing steel with aluminum (data source: GaBi 4.3).

broader view taking into account the entire life cycle, including production and the product use phase, reveals a different picture. A 40% weight reduction would result in the additional CO_2 emissions from aluminum production (compared to steel) being offset in the course of the product use phase. If only a 20% weight reduction were implemented, a break-even would not be achieved within the assumed lifetime of 150,000 km.

From this example two conclusions can be derived:

1. Materials that cause higher emissions in production can nevertheless be environmentally beneficial overall, due to advantages during the product use phase.

2. No material is inherently "good" or "bad". It depends on the specific application of the material, and thus a case-specific analysis is indispensable. In this example the realized weight reduction when substituting steel by aluminum is crucial.

Apart from the definition of system boundaries, for the assessment of environmental impacts it must be decided what impacts to take into consideration. As well as looking at greenhouse gas emissions (measured in kg CO_2-equivalent), cf. Figure 1, further impacts such as acidification, photochemical ozone creation or land use should also be taken into account for a full assessment of environmental performance.

For all these topics the ISO standard 14040 and 14044 for Life Cycle Assessment [2] provides very sophisticated and clear guidelines. Certainly, LCA studies based on ISO 14040 require a considerable effort, but the procedure is indispensable for a reliable assessment of the environmental impacts of raw materials and their applications.

4 ECONOMIC ASSESSMENT

As with the assessment of environmental impacts, for the economic assessment too system boundaries must be defined. This is very much dependent on perspective.

For companies, the economic assessment might at first sight appear straightforward. Raw materials prices are readily available. Taking the example of aluminum versus steel, aluminum results in significantly higher costs: steel prices recently stood at around € 0.60 per kg [3] whereas aluminum cost about € 1.7 per kg [4]. Taking the 40% weight reduction into account, 0.6 kg aluminum would still cost € 1. In this simple economic comparison steel would be preferable.

However, again this is only part of the story. In car manufacturing, further economic aspects must be taken into consideration – for example the cost impact of different body-in-white assembly technologies.

In addition to production costs alone, depending on the perspective of the analysis more comprehensive approaches may be appropriate when making the economic assessment. For instance, the Total Cost of Ownership (TCO) approach could be of interest from the standpoint of customers. The probable higher price of a car with more aluminum parts might be economically acceptable if lower costs during utilization, due to lower fuel consumption, would lead to lower total costs over the life cycle as a whole.

5 ASSESSMENT OF RESOURCE SECURITY

In the current debate on resource efficiency, it is often claimed that it is necessary to reduce resource consumption due to the increasing scarcity of raw materials. However, geologists from various European countries who were part of the European expert group on defining critical raw materials concluded that in general there is no geological scarcity of raw materials [5]. Nevertheless, raw materials prices have increased enormously over recent years and the reasons must be examined. In cooperation with the Federal Institute for Geosciences and Natural Resources (BGR) Volkswagen has developed a methodology to assess raw materials risks [6].

This comprises 5 risk indicators:

- Current supply / demand situation,
- Raw material production costs,
- Geostrategic risks,

- Risk through mining company concentration, and
- The future trend in supply / demand.

Figure 2 illustrates the criteria for the geostrategic risks indicator. The x-axis shows country concentration, the calculation of which is based on the number of countries in which a particular raw material is produced. The highest possible value of 10,000 would mean 100% of a raw material is produced in only one country. On the y-axis the result of weighted country risk, based on the World Bank Index (WBI), is displayed. The WBI consists of six criteria, such as a corruption index, which are aggregated to a risk value for each country. The country risk for a raw material is then weighted according to the respective country's share of world production.

Taking again the example of aluminum versus steel, the criteria used in figure 2 reveal no significant risk for either metal, be it with regard to country concentration or country risk. However, a disaggregated assessment taking into account all five indicators mentioned above might reveal some specific risks for the metals in question.

To summarize, although there is generally no risk of geological depletion of raw materials, industry's access to them could nevertheless be subject to a variety of other risks. Therefore, a range of risk indicators should be applied to identify specific risks for the raw material under consideration. Given the diversity of risks, a corresponding variety of specific measures is necessary to reduce the supply risk. The risk may be reduced through measures such as hedging, diversifying suppliers, substitution or enhanced recycling. However, there is no universal solution; appropriate measures must be considered on a case-specific basis for each raw material.

6 CONCLUSIONS

For the implementation of resource efficiency in corporate management systems a common understanding of the term itself, and also clear objectives, are crucial.

As a first step this paper establishes a clear differentiation between objectives and measures to achieve them. As a second step, assessment methods for the objectives *reducing environmental impacts, improving supply security* and *costs savings* are discussed. The discussed methods are in common use and often already part of corporate management systems. Although the use of these methods might be time-consuming and requires expert knowledge, they are indispensable for the reliable assessment of resource efficiency.

A further key conclusion of this article is that measures aimed at enhancing resource efficiency may involve trade-offs. The presented case study of steel substitution by aluminum to reduce vehicle weight shows potential reduction of environmental impacts on the one hand, but possible negative economic effects on the other. An aggregation of the assessment results for the three objectives to a single indicator, which is the practice currently followed in the resource strategy of the German government [8], is not meaningful, due to the resulting lack of transparency about possible negative effects.

Before any reasonable regulatory measures on resource efficiency can be introduced, it will first be necessary to achieve general agreement on objectives, measures and their effects. This should be a main task of further research work. Companies will have to decide if a specific management system for resource efficiency is reasonable, especially if they have already established sustainability monitoring instruments which pursue almost similar objectives.

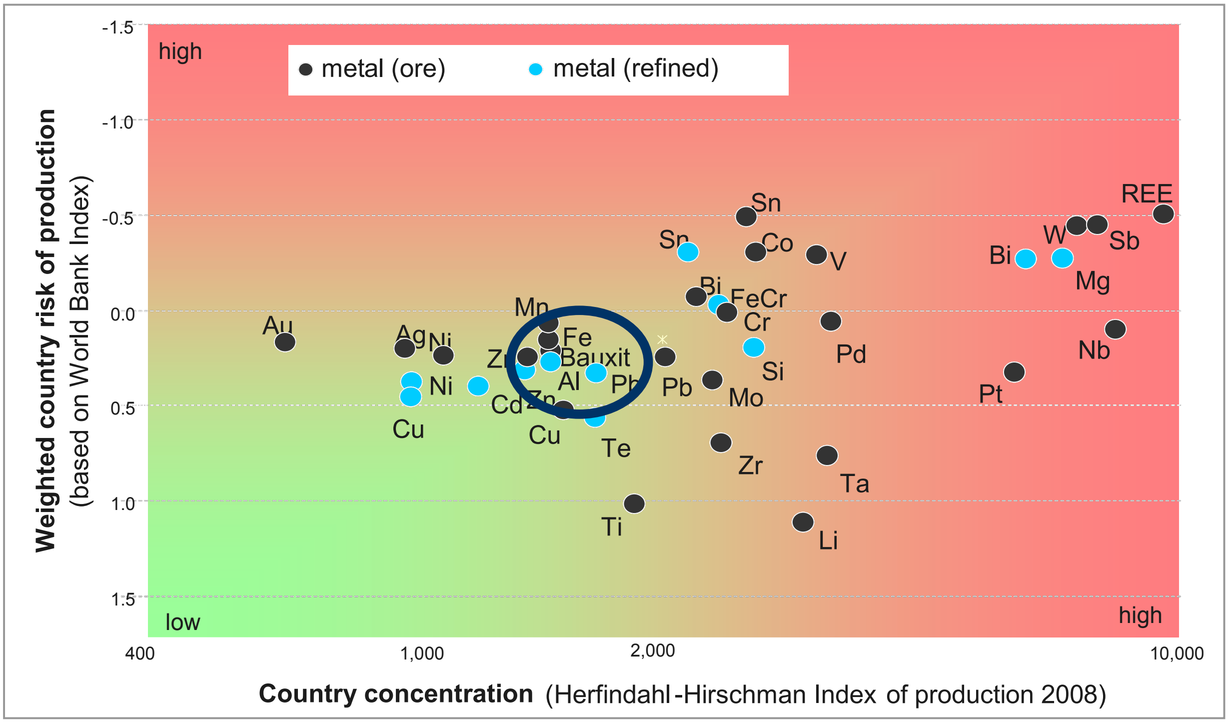

Figure 2: Supply risk criteria, based on [7].

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