



The 6th International Conference on Life Cycle Management in Gothenburg 2013

LIFE CYCLE ASSESSMENT AND CRITICALITY OF RAW MATERIALS: RELATIONSHIP AND POTENTIAL SYNERGIES

*Lucia Mancini**, Serenella Sala, Małgorzata Góralczyk, Fulvio Ardente, David Pennington
European Commission Joint Research Centre, Sustainability Assessment Unit

* Lucia Mancini, European Commission DG Joint Research Centre Via Enrico Fermi 2749
TP270 I-21027 Ispra/Italy lucia.mancini@jrc.ec.europa.eu

Keywords: Life Cycle Assessment; Critical Raw Materials; product policies; Life Cycle indicators, impact assessment methods.

ABSTRACT

The security of supply of raw materials is a policy priority for the European Union (EU). In this paper, different research activities undertaken by the European Commission's Joint Research Centre (JRC), Sustainability Assessment Unit, and related to Critical Raw Materials (CRM) are briefly described. The potential of Life Cycle Assessment for supporting resource policy needs in business and governance is discussed.

Related research activities addressed in this paper include an analysis of impact assessment methods used for the assessment of resources; the Resource Life Cycle Indicators that provide insights into the total environmental pressures of the EU; the identification of potentially relevant requirements for product policies, and the results of the expert workshop "Security of supply and scarcity of raw materials".

INTRODUCTION

The increasing and volatile trend of raw materials' prices observed in recent times reveals that the competition for resources has intensified during the last years. Often, more than just their availability, the access to resources is the main reason of concern.

The Raw Materials Initiative launched by the European Commission started further addressing the problems related to raw materials in order to achieve the goal of ensuring a secure access to these resources for Europe. A list of Critical Raw Materials (CRM) for EU has been published (EC 2010) considering their supply risk and economic importance.

Pressures related to resource use are already encompassed in Life Cycle Assessment (LCA), generally in terms of depletion potential. Thus, consideration is mainly focused on the potential effect of resource extraction on reserves. The security of supply of resources used along the supply chain is not taken explicitly into account by the current impact assessment methods. However, supply chain analysis using LCA has a potential for monitoring the use of CRM and could provide useful information for decision support in business and governance.

This paper provides an overview of research projects conducted by JRC, Sustainability Assessment Unit and related to this topic.

LIFE CYCLE IMPACT ASSESSMENT METHODOLOGIES

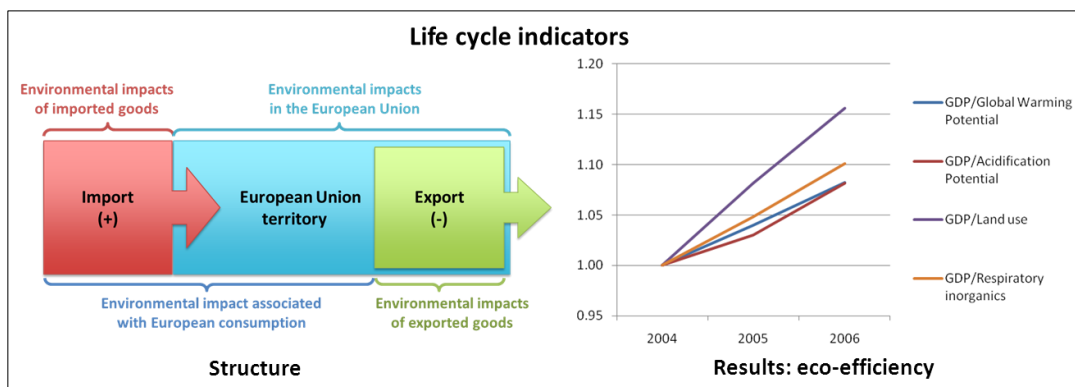
The depletion of abiotic and biotic resources is a fundamental issue for sustainability assessment, entailing and affecting environmental, economic and social aspects. In the context of LCA, resources are already modeled and handled both at the level of inventory (LCI) and at the level of Life Cycle Impact Assessments (LCIA). For inventory, this focuses on the compilation of emissions and resources consumed that can be attributed to specific goods and services. LCIA methods presently consider the resources used in terms of resource depletion in a relatively limited way (Klinglmaier et al 2013): use of natural resources is covered in LCIA mainly in terms of the relative importance of extraction of a resource from the natural environment that leads to a decrease in its future availability. Amongst the methods used in LCIA, the comprehensiveness in terms of number of resources modeled is also different. The resultant rankings depend on the methods adopted, even within this narrow focus. Additionally, only a few of the CRM are modeled by existing methods, highlighting the difference in focus of resource scarcity and criticality methods in current practice.

There are specific research needs in order to foster the capability of LCA and LCIA models to more fully support decision making in the context of resource efficiency and to interact with methodologies for assessing e.g. CRM. The main elements of such research should be focused towards assessing: i) whether criticality should be part of the area of protection “natural resources” in LCAs; ii) how to use results of LCA for comparing CRMs or for identifying a potential substitute material - having the best environmental profile; iii) whether socio-economic implications should even be a part of an LCA or not; and iv) if current LCA indicators and results for resources provide governments and business with the most appropriate information for decision support regarding resource efficiency.

RESOURCE LIFE CYCLE INDICATORS

Resource Life Cycle Indicators provide a comprehensive, aggregated measure for the EU’s (and of each Member State’s) overall use of natural resources and emissions (EC 2012). Resource Life Cycle Indicators combine macro-level territorial resource extraction and emission inventories with the life cycle inventory data for imported and exported products, drawing on trade statistics (Figure 1). Environmental impacts are assessed using Life Cycle Impact Assessment methodologies; hence these cover burdens on the environment, human health, as well as in terms of resource use. Resource Life Cycle Indicators therefore can provide a basis for the assessment of critical raw materials.

Figure 1. Resource life cycle indicators structure and eco-efficiency



PRODUCT POLICIES FOR CRM

A resource-conscious design of products can contribute to reduce supply risk and to ease the pressure on natural reserves. For example, the improvement of design for recycling of the product can make available larger amounts of recovered materials at the product's End-of-Life (EoL). This can be particularly significant for some relevant materials (including CRM) contained in small amounts in products, which are generally lost when specific EoL treatments are not applied.

JRC recently developed a method to help measure, assess and verify resource efficiency of products based on a set of parameters, as: Reusability/Recyclability/Recoverability; Recycled content; Use of priority resources; Use of hazardous substances; Durability (Ardente and Mathieux 2012). The method has been applied to some case-study product groups (Television with LCD - liquid crystal display and washing machines) (Ardente and Mathieux 2012b). Some key components have been identified as important in relation to the content of CRM as, for example, LCD for the content of indium and washing machine's motors, for the potential content of rare earths. The analysis concluded that a design for dismantling of these key components, preventively to shredding treatments, is essential to allow the recovery of CRM.

Potential requirements about dismantlability of key components could be enforced via e.g. implementing measures set according to the Ecodesign Directive (EU 2009). For example Figure 2 illustrates an estimation of the potential benefits in the EU due to the potential enforcement of an Ecodesign requirement on dismantlability of motor in washing machines (fixing the maximum time for the extraction of the motor) (Ardente and Mathieux 2012b).

Figure 2. Assessment of potential benefits provided by the implementation of a product requirement on dismantlability of motors in washing machines (Ardente and Mathieux 2012b)

	A. Overall quantities of metals used in EU 27 (10 ³ kg/year)	B. Quantities of metals used for WMs (10 ³ kg/year)	C. Benefit in terms of additional recycled mass (10 ³ kg/year) brought by the requirement	Fraction C/A	Fraction C/B
COPPER	3.525.913	20.017	500,4	0,01%	2,5%
STEEL	79.926.821	34.695	867,4	0,001%	2,5%
NEODYMIUM		331,6	82,9		25%
PRASEODYMIUM	16.800	82,9	20,7	0,8%	25%
DYSPROSIUM		82,9	20,7		25%
TERBIUM		41,5	10,4		25%

SECURITY OF SUPPLY AND SCARCITY OF RAW MATERIALS: OUTCOMES FROM AN EXPERT WORKSHOP

The Workshop "Security of supply and scarcity of raw materials" brought together experts in LCA and criticality assessment, in order to shed light on the potential of supply chain analysis in supporting resource policy. The state of the art in impact assessment methods for resources and in methodologies for identifying critical raw materials was discussed during the two days meeting.

The discussion held between participants led to conclude that a re-think and re-design of the impact category "Resources" is needed in assessments such as LCA. In particular it was acknowledged that, in addition to scarcity issues, socio-economic factors that can prevent the

access to raw materials (i.e. the supply risk) should also be taken into account. However, some mismatches have been identified between methodologies for assessing criticality and LCA, which could make the inclusion of criticality aspects at impact assessment level controversial. For these reasons, the inclusion of criticality aspects in LCA – that has been suggested by workshop participants – could be better placed at inventory level.

However, the consideration of resource security aspects in LCA – which shouldn't be limited to the environmental aspects but should instead capture all the impacts along the supply chain – has been recognized as a relevant development that could enhance the capability of LCA in supporting policy objectives related to resources and that is consistent with some existing elements of e.g. LCA in current practice (Mancini, De Camillis, & Pennington, 2013).

CONCLUSIONS

This paper provides a brief overview of different research activities undertaken by the Sustainability Assessment Unit of Joint Research Centre, and linked to the topic of CRM. The developments highlight the potential of Life Cycle approaches for detecting flows of CRM within economies; identify major research gaps of the current impacts assessment methods used for assessing resource related pressures; suggests how an improvement of design for recycling can support more efficient use of critical resources.

We suggest that approaches such as Life Cycle Assessment are well positioned for a methodological enhancement to better reflect the consideration of security of supply aspects and to give improved support to resource policy. This information could provide governments and business with more appropriate information for decision support and for reducing supply risks associated with materials' provision.

REFERENCES

- Ardente, F., Mathieux, F. (2012). Refined methods and Guidance documents for the calculation of indices concerning Reusability/Recyclability/Recoverability, Recycled content, Use of Priority Resources, Use of Hazardous substances, Durability. Joint Research Centre Technical Report. (<http://lct.jrc.ec.europa.eu/assessment/projects#d>). Doi: 10.2788/42590
- Ardente, F., Mathieux, F. (2012b). Application of the project's methods to three product groups. Joint Research Centre. Technical Report. (<http://lct.jrc.ec.europa.eu/assessment/projects#d>). Doi: 10.2788/75910
- EC - European Commission (2010). Critical Raw Materials for the EU. Report of the Ad-Hoc Working Group on Defining Critical Raw Materials. EC. Brussels.
- EC - European Commission (2012). Life cycle indicators for resources: development of life cycle based macro-level monitoring indicators for resources, products and waste for the EU-27. European Commission, Joint Research Centre, Institute for Environment and Sustainability
- European Union – EU. (2009). Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of Ecodesign requirements for energy-related products (recast).
- Klingmaier M., Sala S., Brandao M. (2013) Assessing resource depletion in LCA: A review of methods and methodological issues *accepted for publication in IJLCA*
- Mancini, L., De Camillis, C., Pennington, D. (eds.) (2013). Security of supply and scarcity of raw materials. A methodological framework for sustainability assessment. Joint Research Centre (in press)