Department for Environment, Food and Rural Affairs

Hazardous Substances Advisory Committee

HSAC paper on definition of lifecycle/value chain in relation to nanomaterials and other manufactured substances

February 2017

Recommendation on a UK position on the definition of lifecycle/value chain in relation to nanomaterials and other manufactured substances

The UK is keen to use advances in nanotechnology to improve the environment, for example in the contexts of environmental sensing, pollutant remediation and the development of more environmentally friendly substances. There is, however, a lack of clarity in how nanomaterials interact with the environment and the terminology surrounding the assessment of such interactions. Across Europe the terms Life Cycle and Value Chain are used without clear definition and often interchangeably.

The purpose of this paper is to help policy makers to understand the terms Life Cycle and Value Chain as they relate to chemicals in the environment. It aims to clarify the distinct meanings of the two terms and recommend their appropriate use in different contexts, particularly those focused on economic or environmental policy, and the implications thereof.

Definitions

A number of definitions of the terms Value Chain and Life Cycle (and the related term Life Cycle Assessment) are available. The list below is not meant to be exhaustive but exemplifies some of the clearer ones available from reputable sources.

'Value Chain'

The Cambridge Business English Dictionary[1] defines Product Value Chain as “all the activities involved in making and selling a product, and any service provided after it has been bought, which together create the product's value”.

A similar definition is provided by Investopedia:[2] “A high-level model of how businesses receive raw materials as input, add value to the raw materials through various processes, and sell finished products to customers”.

[1] http://dictionary.cambridge.org/dictionary/english/product-value-chain

These definitions indicate that the term Value Chain is limited in its scope as it stops with the purchase of the product and does not address subsequent events such as the use, disposal and ultimate fate of the material. Thus, interactions with the environment are not considered in a Value Chain analysis.

'Life Cycle'

ISO 14040 "Environmental management -- Life cycle assessment -- Principles and framework"[3] defines Life Cycle as "consecutive and interlinked stages of a product system, from raw material acquisition or generation from natural resources to final disposal" and Life Cycle Assessment (LCA) as "compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle"

It goes on to describe LCA as a technique for assessing the potential environmental issues associated with a product (or service), by: compiling an inventory of relevant inputs and outputs, evaluating the potential environmental impacts associated with those inputs and outputs, interpreting the results of the inventory and impact phases in relation to the objectives of the study.

In an LCA, a cradle-to-grave systems analysis of the production, use and disposal of a product or service is usually undertaken, providing a comprehensive evaluation of all upstream and downstream energy inputs, resource consumptions and environmental emissions. The LCA approach is therefore, in principle, preferable to Value Chain analysis when the environmental impact of products or services is to be considered. However, LCAs can be costly and time-consuming due to the usually high requirement for extensive inventory data, thus limiting their use in both the public and private sectors. Streamlined techniques for conducting LCAs are available to reduce the cost and time involved and to encourage a broader audience to begin using LCA.

It should be noted that the concept of LCA, often referred to as Life Cycle Thinking, can also be applied to the social and economic pillars of sustainability in the guise of social LCA [4] and Life Cycle Costing[5]. The social LCA and Life Cycle Costing approaches consider systems and system boundaries equivalent to those used in an environmental LCA to assess a given process or service; however, in these cases the inventory is populated with data relevant to the social or economic dimensions. The impact categories in social LCA are clearly different from those in environmental LCA and will include attributes such as working conditions, health & safety, cultural heritage and governance, which can be difficult to quantify. As the name implies, Life Cycle Costing considers the economic costs associated with a product or service throughout its life cycle. Social LCA is currently under active development and has

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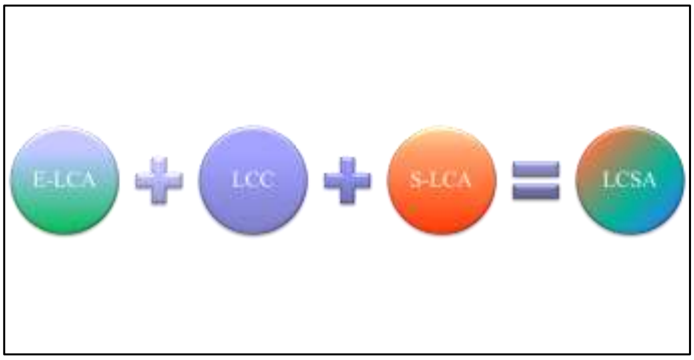
[2] http://www.investopedia.com/terms/v/valuechain.asp
[3] https://www.iso.org/obp/ui/#iso:std:37456:en
[4] http://www.unep.org/pdf/DTIE_PDFS/DTIx1164xPA-guidelines_sLCA.pdf
[5] http://ec.europa.eu/environment/gpp/lcc.htm

several aspects that are the subject of debate and controversy; it cannot, therefore, yet be regarded as a mature methodology.

Ultimately, there is interest in combining LCA, social LCA and Life Cycle Costing into an overarching, integrated assessment known as Life Cycle Sustainability Assessment[6] as illustrated in Fig 1 below[7].

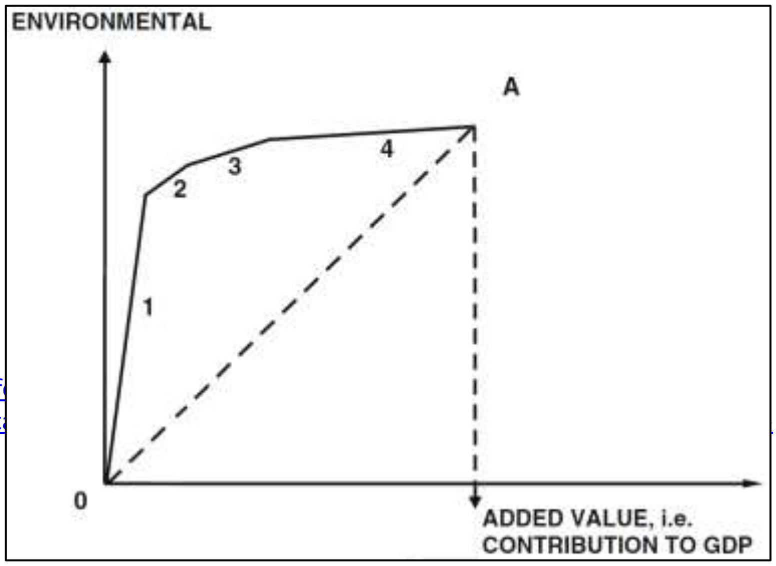
Figure 1. Combination of 'traditional' environmental LCA with Life Cycle costing and social LCA to give Life cycle Sustainability Assessment (after UNEP, 2011[7]).



Comments

There is a clear difference between the meaning of the terms Value Chain and Life Cycle, and between the approaches to which they relate. Value chain generally focuses on 'value added' up to the point of sale to the customer, in other words, the point at which the commercial value of the product has been maximised. The value chain is measured relatively easily in terms of the prices paid by producers for the inputs and by the final consumers up to the point of sale. It does not take into account additional monetary costs associated with disposal and remediation, which would potentially have a detrimental impact on the overall value of the product and the environment more generally, including long-term consequences for human health. Value chain analysis is useful in indicating where the biggest increments of value are added across the product's generation e.g. in extraction of raw materials, pre-manufactures, manufacturing or final assembly etc. as seen in Fig 2.

Figure 2. Accumulation of added value (i.e. contribution to GDP) and environmental impact along a supply chain for a manufactured product.
1. Resource extraction



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[6] http://www.unep.org/pdf/UNEP_Lif
[7] http://www.lifecycleinitiative.org/st
assessment/

2. Processing & refining
3. Manufacturing
4. Retail & distribution (A = finished product in use)

(after Clift, 2003[8])

Some of these additional costs will be incurred in monetary terms by producers in the process of disposal and remediation. There are, however, further costs, which usually are not monetised, specifically the "negative externalities" i.e. the indirect hidden costs imposed on those people who are not directly involved in the exchange of value. For example, the environmental impacts of nanomaterial production may have implications for human health and wellbeing. As for any polluting production, the polluter does not pay, unless there is government intervention (e.g. in the form of regulation, taxes, or artificial markets in the form of pollution permits). A properly conducted LCA can take into account monetary costs, including aspects of a product's cost and value from the acquisition of the raw material to the ultimate disposal and, where relevant, environmental degradation of the product. Both LCA and Value Chain approaches are useful, as they have overlapping scopes yet assess different endpoints. Neither, however, addresses the negative externalities imposed on wider society if the production of nanomaterials is associated with increased pollution (unless data is known however this often leads to an environmental impact assessment through monetised metrics). Some of these negative impacts could also have implications for the government's fiscal positions if they lead to increased pressures on health spending in the long-term. These indirect impacts are often subject to high degrees of uncertainty.

Recommendation

When deciding whether to adopt a LCA or Value Chain approach to evaluating the economic and environmental impact of a nanomaterial or other manufactured substance, it is important to ensure that the most appropriate approach is used depending on the specific context. Both approaches have value, but only if they are used consistently and correctly. In particular, there may be the temptation to use whichever approach will generate data conveying the best impression; for example, value chain will usually capture the maximum economic benefit from a product and is therefore likely to be preferred by departments with a strong focus on economic returns such as the Department for Business, Energy & Industrial Strategy.

Within the overall responsibility of Defra, HSAC's remit is to consider the environmental impact of substances across their entire life cycle and it should, therefore, usually consider a full LCA not just a value chain analysis. By the same token, given Defra's remit, the committee recommends that the LCA approach is

[8] Clift, R (2003). Metrics for supply chain sustainability. Clean Tech Environ Policy 5, 240–247 DOI 10.1007/s10098-003-0220-0

used as widely as possible when assessing new and emerging hazards, including those relating to nanomaterials.

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