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CML-IE

Criticality and Abiotic Resource Depletion in LCA

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Ester van der Voet

Scarcity, criticality and depletion

- Depletion: the amount of a specific resource is reduced
- Scarcity: the amount of a specific resource, that is used in society, is/will be insufficient
- Criticality: the resource may be scarce, and is also important.

Scarcity, criticality and depletion

- Depletion:
  - Geological / natural reserves on the planet
- Scarcity:
  - All stocks on the planet that can be profitably accessed (economic availability)
  - Political / social / environmental availability
  - Rate of extraction
- Criticality: resource may be scarce, and is important for society as well
  - Substitutability
  - Future applications, expected future demand

Abiotic depletion in LCA

- Abiotic depletion is artefact of wishing to isolate problems within clear system boundaries of economy and environment
  - “reserve” depends on (future) technology
- Artefacts can only be cured artificially
  - there is no “correct” way, not even in theory
- Assessment of depletion problem can never be completely verified empirically
  - one cannot truly validate a non-empirical method

Abiotic depletion in LCA

- As a consequence, it is one of most frequently discussed impact categories
  - consequently a wide variety of definitions and methods available
  - different methodologies reflect differences in problem definition

Abiotic resources: definition

- Natural resources (including energy resources) such as iron ore, crude oil and wind energy which are regarded as non-living

Abiotic resources: definition

- Deposits: not regenerated within human lifetimes
  - fossil fuels, minerals, sediments, clay, etc.
- Funds: regenerated within human lifetimes
  - groundwater and soil
- Flows: constantly regenerated
  - wind, river water, solar energy (*competitive use*)

- Difficult to combine

There are other (problem) definitions, however ...

At least, four problem definitions can be distinguished:

A. decrease of resource itself
B. decreasing world reserves of useful energy / exergy
C. contribution of current extraction processes to other impact categories
D. change in environmental impact of extraction processes at some point in future (e.g. result of having to extract lower-grade ores or recover materials from scrap)

And thus also many methods

Aggregation and assessment based on:

method description	examples	problem def.
none	Lindfors, 1996	C
mass of resources extracted	Lindfors et al., 1995c	A
'ultimate reserves' or 'economic reserves', and/or current extraction rate	Heijungs et al., 1992; Guinée & Heijungs, 1995; Ekvall et al., 1997; Goedkoop, 1995; Hauschild & Wenzel, 1998	A
cost of 'restoring' the resource to its original, natural state, or on the costs associated with substituting current extraction processes by presumed 'sustainable' processes	Pedersen, 1991; Steen, 1995	C, D
energy content or exergy content or consumption	Finnveden, 1996b; see also Ayres et al., 1996 and Ayres, 1998	B
change in the anticipated environmental impact of the resource extraction process due to lower-grade deposits having to be mined in the future	Blonk et al. (1997a) and Müller-Wenk (1998) in Goedkoop & Spriensma, 1999	D

ICLD assessment

Table 27 Summary of the analysis of six midpoint characterisation methods against the adapted criteria for resources.

	Exergy		Swiss Ecoscarcity energy		CML2002		EDIP2003		MEEuP		Swiss Ecoscarcity water	
Category	**Category 1**		**Category 1**		**Category 2**		**Category 2**		**Category 3**		**Category 3**	
Completeness of scope	A	The model is very complete. It covers minerals, fossil fuels and flow resources (including, solar, wind, hydropower and water).	C	The model is relatively complete for energy resources, with an interesting but Swiss specific correction factor for renewability.	C	The model is relatively complete for mineral and fossil-fuel depletion.	C	The model is relatively complete for mineral and fossil fuel-depletion. An attempt for water use and wood extraction is made.	E	The model includes adding up water amounts, but does not differentiate according to regional differences in water scarcity.	C	The model is relatively complete for water depletion, in a regionally-specified way.
Environmental relevance	C	Very complete implementation of the exergy concept. However, this method does not reflect scarcity.	C	The renewability factor is a new concept, but needs elaboration to become useful.	B	Characterisation factors for economic reserves, reserve base , and ultimate reserves are available. Antimony is the reference resource adopted.	C	Based on 1990 extraction rates and economically-exploitable reserves. Does not capture importance of a resource well, since extraction rates are not included. Water impact is not applicable, only one CF for all types of wood.	D	Simplistic environmental model for assessing the impact of water.	B	The model assesses water depletion on a regional basis. Recovery rates are included.
Scientific robustness & Certainty	B	The paper is reviewed by external experts. Uncertainties are described but not quantified.	E	There is only a very rudimentary scientific model.	B	The paper is reviewed by external experts. Uncertainties are described but not quantified.	C	The paper is reviewed by external experts. High uncertainties arise in the economically-based reserves calculations, but these are not quantified.	E	There is no scientific model.	C	The paper is not reviewed yet, proposed by the UNEP-SETAC Life Cycle Initiative but suggested in SETAC UNEP results. Uncertainties are discussed but not quantified.
Documentation, Transparency & Reproducibility	A	The model and results are very well documented.	B	The model documentation and results are so far only available in German.	A	Documentation is available online. The website has descriptions and factors.	A	The model documentation and results are easy available.	A	The documentation is easily available.	B	The model documentation and results are so far only available in German.
Applicability	A	Characterisation factors are available and can be easily applied.	A	Characterisation factors are available and can be easily applied.	A	Characterisation factors are available and can be easily applied.	A	Characterisation factors are available and can be easily applied.	A	Characterisation factors are available and can be easily applied.	B	Characterisation factors are available and can be applied when country is specified.
Science-based criteria	B	The model is very complete. However, there are different views on whether exergy is a relevant indicator.	C	Mixture of science and Distance-to-Target.	B	Robust method for mineral resources. characterisation factors for available for economic reserve, reserve base, and ultimate reserves.	B	Robust method for non-renewable resource depletion, which is based on economically-exploitable reserves.	D	Too simplistic for consideration as a science based method.	B	Promising approach for water use.
Stakeholders acceptance	C	It is not clear whether policy-makers are interested in using exergy as a resource indicator.	D	This method is mainly interesting for Swiss policymaking.	B	The principles of the method are relatively easy to understand, but the model is not endorsed by an authoritative body.	B	The principles of the method are relatively easy to understand, but the model is not endorsed by an authoritative body.	E	Simple method, not endorsed by an authoritative body.	B	The principles of the method are relatively easy to understand, but the model is not endorsed by an authoritative body.

ICLD assessment

ICLD concludes:

- No ideal method
- Recommended methods:
  - CML 2002 (level II)
  - Swiss ecoscarcity for water (level III)
  - ReCiPe (interim).

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Abiotic depletion in LCA

Depletion, scarcity, criticality?

- Methods address physical scarcity
  - Reserves, availability, rate of extraction
  - No societal aspects
- Methods do not address criticality
  - No statement on importance
  - Nor on future demand

- Should they?
- If so, how?

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Criticality in LCA

Should they?

Arguments for:

- Relevance, link to present highly prominent debate

Arguments against:

- Criticality aspects depend on values, not facts: is a statement on the severity of scarcity for society.

Criticality in LCA

If so, how?

Societal aspects of scarcity:

- Highly context dependent
- Similar to location dependent emissions…
- … but resource market is global, even if resource deposits are local
- (except water)

Criticality:

- Importance as part of weighting?
- Weighting factors to be established, based on perceived importance?

Development of abiotic depletion in LCA

- Depletion is quite as complex as pollution
- Different depletion impact categories based on (physical) characteristics of resources, for example
  - Metals
  - Fossil fuels
  - Surface minerals
  - Nutrients
  - Water
  - Land
  - …

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Development of abiotic depletion in LCA

- Should not be confused with emission impacts related to extraction
  - they have their place already in LCA
- Depletion: an economic or an environmental problem?
  - in or out?
  - treatment of societal aspects?
- Normalisation and weighting procedures to be developed
- End point methods also to be developed
- Criticality aspects can be part of those.