# SWC Hybridisation Guide

**Integrating process-based life cycle analyses (LCAs) into spend-based environmentally extended input-output (EEIO) emissions estimates for company supply chains.**

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# Introduction

The goal here is to combine the system-completeness of spend-based estimates with the specificity of LCAs without incurring system boundary inconsistencies, which would otherwise be likely to have serious consequences for the overall realism of the assessment. The approach outlined begins with a spend-based emissions analysis, into which elements of LCA are substituted. To maintain the system-completeness of the spend-based EEIO approach, each LCA system boundary is mapped onto a structural path decomposition of the corresponding spend-based emissions factor. It is then possible to estimate the proportion of the EEIO system which lies outside the LCA. Since many LCA guidelines adopt similar boundary criteria, a pre-prepared set of industry-specific adjustment mark-up factors can be used.

# EEIO, LCA and hybrids

All company supply chain emissions assessments are approximations with considerable uncertainty. Nevertheless, it is possible, practical, and important for organisations to develop ‘good enough’ footprint estimates in order to be able to prioritise areas for reduction, set targets and track changes over time. Emissions assessments should be transparent, impartial and complete. A degree of compatibility between the methods adopted by different organisations is highly desirable.

Spend-based emissions factors, derived using environmentally extended input-output analysis (EEIO), have two important advantages:

They are relatively easy to use, since the only activity data requirement is company spend categorised by the source industry for an organisation’s supply chain.

The entire supply chain system is included; all the supply chain pathways are followed to infinity, without truncation.

However, a severe disadvantage of EEIO-based emissions factors is that they are extremely generalised. They do not reflect the specifics of a product or service within an industry category, or of the supply chains used, and they spuriously reflect price changes as changes in embodied carbon intensity.

At its best, LCA stands to achieve much higher specificity. However, detailed LCA is resource-intensive, often omits supporting activities relating to production of goods and services, and always incurs a truncation error.

> Note: if secondary emissions factors are employed, the specificity that LCAs stand to offer can still easily be lost. It is also generally impossible to conduct an LCA for every supply chain component due to the resources required to obtain this information.

A hybrid analysis, in which elements of LCA are substituted into an EEIO-based model, can attain the most realistic overall results from any given resource. When conducting such analysis, it is important to honour the system-complete boundary condition of counting every supply chain pathway but without double-counting. If this is not done, there are likely to be serious or show-stopping implications for the realism of the end results.

# An outline hybridisation method

Various methods for hybridisation are possible, but the step-by-step process outlined here for an organisation's supply chain is the one we have found to be most practical, and to provide the greatest realism most of the time. A similar approach can be applied to a product or service.

**Step 1**: Categorise the entire supply chain spend according to the industry categorisation of the EEIO model. Where possible, if a multi-regional EEIO model is being used, also categorise by region of production and/or demand. (SWC's multi-regional model provides separate sets of emissions factors for categorising spend by either country of production or country of procurement.)

**Step 2:** Multiply each component of the spend by the emission factor taken from the EEIO.

**Step 3:** Identify key areas of spend-based estimates, where replacement with physical consumption data and emissions factors derived from primary or secondary LCAs can improve quality. Such areas typically include the following:

- Supply chains of energy use.
  *Note: EEIO does not cover an organisation's direct emissions. It can be used to make a first estimate of energy supply chain emissions, since physical consumption data and relatively high-quality supply chain emissions factors are easy to obtain. This can then be improved upon.*
- Travel and transport.
  *Note: spend-based emissions factors include entire transport supply chain emissions as well as emissions from vehicle fuel combustion. LCA-based emissions factors used in substitution should approximate the same system-completeness as far as possible, most notably covering fuel supply* chains, *vehicle manufacture and maintenance. Commuting emissions are not generally included in the spend-based model since they are not purchased by the organisation.*
- Key materials, products, and services in the supply chain for which consumption data and emissions factors are available.
  *Note: the priority for selecting supply chain components for LCA substitution should be based on a blend of factors: the expected significance of emissions; availability of consumption data; availability of high-quality, representative process LCA-based emissions factors; the extent to which each element of spend is thought to be typical in terms of emissions of the industry into which it is categorised.*

**Step 4:** Apply a truncation error adjustment factor to each process-based emissions factor. These factors are industry-specific and adjust for the truncation resulting from differences in the system boundary condition of each LCA (see Appendix).

**Step 5:** Replace components of the spend-based estimate with hybridised components in which physical consumption data is multiplied by adjusted LCA emissions factors.

**Step 6:** Wherever hybridisation has taken place, a sense check should be carried out to gain a real-world understanding of any significant differences between the EEIO- and LCA-based estimates. If these cannot be reconciled, it may indicate an error in the analysis.

If increasing hybridisation, it may be desirable to run several iterations, progressively increasing the specificity and accuracy of the results as improved data becomes available; this reinforces the requirement to reflect the effect of every type of mitigation action taken in any part of the supply chain.

# Appendix: Development of adjustment factors for integration of LCAs into spend-based emissions assessments.

In order to blend estimates drawn from physical consumption data and LCAs into EEIO spend-based assessments, adjustments have to be made for differences in the system boundary conditions and the truncation error that is inherent in LCAs. This can be very significant and depends upon the type of product or service (i.e. the industry that produces it), as well as the specific methodological choices made in both the EEIO model and the LCA. It is not possible to make a perfect adjustment, but it is possible to make a realistic adjustment that is much better than ignoring the issue. There is sufficient commonality between most LCA standard guidelines that it is possible to produce a usable and convenient table of generic adjustment factors, covering key industries and the most common permutations of significant system boundary differences between any given EEIO and any credible LCA.

The key factors we take into account in developing such a matrix of adjustment factors are as follows:

Whether or not capital investment has been included within the system boundary. For example, whether building a factory to manufacture a product is considered to be part of production of the product. This varies between EEIO models and between LCAs. (At SWC we take the view that it is more useful to include this within the system boundary, and therefore in almost all our work we use an EEIO that includes it.)

Whether or not radiative forcing effects of high-altitude emissions from aviation have been included in the model. (In SWC's models they are included, since the purpose of the analysis is to understand climate change impacts, of which these are a significant component. Unhelpfully, in our view, at the time of writing Google excludes them from its online flight emissions calculators.)

Whether or not tertiary activities have been included (e.g. product design and marketing, the cleaning of a factory, the running of office facilities relating to a factory). All EEIO models include these, but they are usually beyond the scope of LCAs.

The significance cut-off level. LCAs generally have cut-off criteria that allow the exclusion of smaller supply chain pathways whose significance is estimated to be below a certain level (e.g. 1% of the total). EEIOs are system-complete, with no cut-offs.

To produce mark-up adjustment factors for LCA-based emissions factors, we run a version of the EEIO model for each permutation of inclusion/exclusion of the above variables to quantify their effect. Activities that are tertiary to a product or service LCA vary from industry to industry and are mapped out through a structural path decomposition. Some judgements with a subjective element are necessary at this stage. For each permutation of 1, 2, and 3, different significance level cut-offs can be imposed onto the EEIO to approximate the impact.


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