INTEGRATING SUSTAINABILITY IN ASSET MANAGEMENT DECISION MAKING: A CASE STUDY ON STREAMLINED LIFE CYCLE ASSESSMENT IN ASSET PROCUREMENT

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ABSTRACT

DSO's are increasingly expected and motivated to improve the environmental impact of their assets. A key improvement opportunity can be found in the procurement process, as most characteristics that determine an asset's environmental impact are committed at this stage. Many DSO's look to LCA as the international industry standard for assessing and quantifying environmental impact. Full LCA however, is too complex and tedious to be pragmatically used in procurement processes, as these require simplicity and accessibility to provide equal opportunity for all participants. By only including only the most dominant input & output parameters of a "master" LCA, the process of performing an LCA on a specific asset can be greatly simplified. This simplified model is demonstrated and evaluated through a case study on the procurement of medium voltage switchgear. The streamlined LCA approach presented in this article maintains most of the relevance of full LCA, while greatly reducing the complexity and resources required for its use.

INTRODUCTION

As one of the larger energy Distribution System Operators (DSO's) in the Netherlands, Liander has increasingly become aware of the sustainability of its energy distribution systems. Currently, several initiatives exist for improving its sustainability impact. As an asset management organization, Liander also wants to consider sustainability characteristics of its assets alongside traditional criteria like costs, performance, and compliance. As a part of a broader supply chain, the impact of the assets goes further than Liander's own bottom line, and so a life cycle perspective is required. Fabrycky and Blanchard [1] estimate that "50% to 75% of the projected Life Cycle Costs (LCC) of a given system are committed (i.e., 'locked in') based on engineering design and management decisions made during the early stages of conceptual and preliminary design". The environmental impact potential of an asset is similarly determined in the early stages of development. A DSO, however, only has a limited direct influence on these design stages, as the actual design of the asset is carried out by the manufacturers, who mainly base their decisions on the expected requirements of DSO's. While it is technically possible to develop more environmentally friendly assets, manufacturers indicate that environmental impact is not always taken into account in the procurement process. As (the development of) more environmentally friendly assets are typically accompanied by higher costs, manufacturers are stimulated to forgo environmental improvement by procurement procedures that are mainly decided by technical performance and price. Overall, sustainable products and production of energy distribution assets are still in the early stages of development.

As DSO's have critical roles in the asset selection process, they carry a social responsibility to take into account environmental impact in their procurement processes. However, Liander sources its assets internationally, mainly on the European market where knowledge, standards and supporting legislation varies among countries and where EU rules, standards or systems are not always in place. An internationally accepted approach to assessing a product's environmental impact over its entire lifecycle can be found in Life Cycle Assessment (LCA). Typical applications of LCA are in identifying opportunities for improving environmental performance, marketing and informing decision makers in industry and governmental & non-governmental organizations [2]. As the industry standard for assessing environmental impact, Liander intends to use LCA in its procurement processes.

PROBLEM STATEMENT

The standardization of LCA in the ISO 14040 series standards has both harmonized and increased the credibility of the methodology over the last few decades, leading to its widespread adoption in industry. The industry, however, also revealed the need for simplifications for many applications. Hence, streamlined life cycle assessment methods have been derived from experience with the complex full methods [3].

Procurement is a prime example of an application that can benefit from simplification as its process should be accessible and transparent whereas "full" LCA can be difficult and tedious for the designers [4]. If DSO's intend to implement streamlined LCA for procurement of assets alongside other criteria of the procurement, a practically applicable approach to streamlined LCA is required as well as a means to subsequently integrate the results into the decision-making process of tenders. Currently, no clear solutions exist for this specific topic. Some DSO's have adapted LCA models intended for other industries (e.g., construction sector). However, these adaptations are not always aligned with the context of DSO asset management or are performed by people lacking a suitable level of LCA expertise. Consequently, these approaches tend to lack scientific rigor, use outdated data, have procedural errors and often only assess a single indicator (usually CO_2). So, a new approach is needed that takes a broad view of environmental impact and is developed specifically for the procurement of assets by DSO organizations.

DESIGN OF A STREAMLINED LCA MODEL

The objective of this research is to design a practically applicable method for implementing streamlined LCA in the process of asset procurement.

Design criteria

Rebitzer et al. [5] proposed criteria for streamlined LCA methods, citing relevance, validity, compatibility with computational procedures, reproducibility and transparency as the main principles. These principles are adapted into five design criteria that a simplified LCA model for use in asset procurement should meet:

- ***Relevance*** – To ensure accessibility and equal opportunity for all potential procurement participators, the procurement should be usable without expert knowledge on LCA or access to specialized LCA software and/or databases.
- ***Validity*** - To ensure validity, the results of a simplified LCA should not deviate more than 95% from that of a comprehensive LCA using similar goal & scope definitions.
- ***Compatibility with computational procedures*** - To enable the integration of environmental impact into a single procurement score, the outcome of the simplified LCA should be compatible with other procurement criteria (e.g., costs, design criteria, etc.)
- ***Reproducibility*** - Different practitioners should arrive at the same LCA score or ranking result given identical asset characteristics (and goal & scope definitions).
- ***Transparency*** - In order to be credible (i.e., remove any doubts about the model) and to identify improvement potential, the method should be transparent. In other words, it should be feasible for a practitioner to understand the calculation of the final result and origins of the main environmental issues.

Relevance is addressed by simplifying both the input and output models of the LCA model by only including the most dominant elements, thus reducing the time and expertise required to create a Life Cycle Inventory (LCI) and to interpret the results. A spreadsheet model is used for the assessment of a group of similar products. This model incorporates unit process data for the relevant processes in the life cycle of the product. ***Compatibility with computational procedures*** is achieved by monetizing the outcome of the streamlined LCA and aggregating the monetized impact alongside financial impact. ***Reproducibility*** **&** ***transparency*** are ensured by modelling the streamlined LCA using spreadsheet models, which are identical for all potential procurement candidates. This model shows intermediate results to allow for easier interpretation and improvement analysis. ***Validity*** is achieved by comparing the outcome of the streamlined LCA with the outcome of a comprehensive LCA.

Simplification of LCA input & output models

LCA is a general instrument that is developed to be compatible with a wide range of possible applications. As such, some environmental indicators that are included in various Impact Assessment Methods (IAM's) are more relevant than others, depending on the context of the application. In procurement, however, the goal & scope of the LCA can be set by the DSO. As the application context is exactly the same for all potential suppliers, indicators that do not contribute significantly towards endpoint effects can be cut-off from the scope (ignored) without compromising accuracy. It is expected that a significant reduction in the number of indicators can be achieved when limiting the scope accuracy at the endpoint level (e.g., at 95%). The reduction in the number of indicators drastically decreases the complexity of the LCA's output model and simplifies the interpretation of the results by only returning the most dominant environmental impact results. To allow the supplier to interpret the environmental impact of the asset, the tool provides feedback on both midpoint and endpoint impacts. Similarly, the input model can also be simplified as not all processes in the LCI model are dominant in their contribution to the endpoint damage. Streamlining efforts at the LCI phase have the greatest potential for savings, as it is the most time-consuming phase of LCA [5]. Using the strategy of selecting only the most dominant processes and resulting energy & material flows in the LCI model, a greatly simplified and reduced input model can be constructed, once again trading-off little relevance.

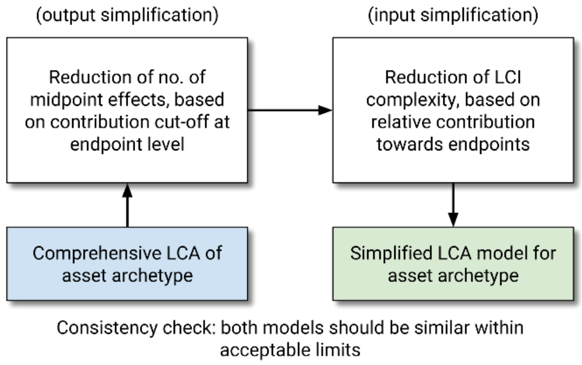

Fig. 1: Conceptual model of LCA simplification process

In the selection of the LCI processes, it is important to consider whether the suppliers are be able to (easily) provide this data. This information into the dominant aspects in an asset domain can be used to develop a simplified (streamlined) LCA model that can be practically applied in existing tender processes (fig. 1).

Monetization

One way to integrate the financial impact for the decision maker and the environmental impact of that decision is to combine streamlined LCA with LCC analyses [6]. In this approach, the direct costs of the decision making organization are combined with indirect and less tangible environmental costs. This approach requires a monetization step where the environmental burdens are given a monetary value. Based on multiple case studies, Kara, Manmek & Kaebernick [7] conclude that streamlined LCA and monetization is an effective approach to evaluate environmental impact of a product as early as the conceptual design stage of a product. By integrating environmental and cost performance, a better understanding can be gained about inherent trade-offs and optimization options in the asset lifecycle.

Integration in tendering process

In the tendering process, simplified LCA results are included as a surplus external cost, by using the simplified LCA tool and assessing monetized environmental cost and adding these to the total cost of ownership and the other assessment criteria (fig. 2). Suppliers can use the tool to generate simplified LCA results, by modelling the lifecycle characteristics of their asset using the preselected input parameters of the spreadsheet model. The LCA result – at endpoint level: damage to human health in DALY, damage to ecosystems quality in species•years, and damage to resource availability in surplus costs to extraction – are subsequently monetized, based on internal valuation of the DSO and values from relevant academic literature, to find environmental costs (in €).

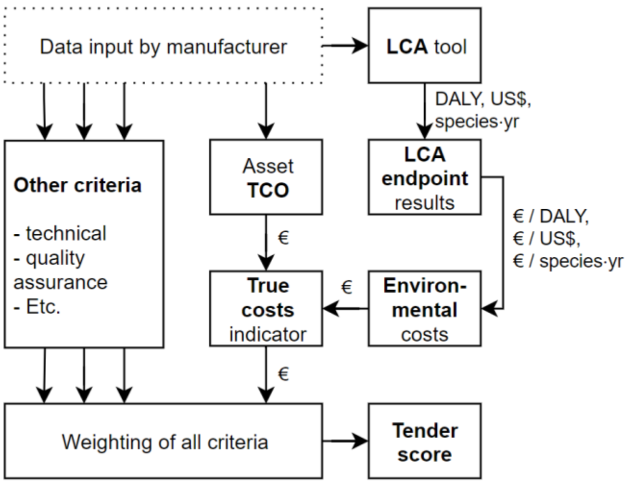

Fig. 2: Inclusion of LCA in the tendering process

The environmental costs are then added to Total Cost of Ownership (TCO, also in €) to find a True Cost Indicator (TCI). This TCI is then used in the tender weighting table as if it were the actual price, thus comparing it to the other decision criteria. Tender entries from different manufacturers will subsequently be ranked based on their final tender score.

CASE STUDY

The proposed streamlined LCA approach was demonstrated with a case study on medium voltage switchgear. Historical data from a previous tenders was used to evaluate the developed approach. The use of historical data not only removes issues with data acquisition (tender processes can take more than one year to complete), it also imposes realistic limitations on input data requirements. If the new method is applicable using only existing data, it's data requirements are not likely to be more complex than that of existing tenders. This ensures the relevance and the ability of suppliers to provide the required data (they have proven to do so in the past). Furthermore, it uses the same stakeholders and intended processes to simulate a real-world context.

Output simplification

In the case study, the ReCiPe 2016 [8] IAM was used as this method is widespread in industry and scientific literature and contains both mid- and endpoint indicators. The mid-to-endpoint characterization factors were used to reduce the 17 midpoint indicators of ReCiPe down to only four midpoints, based on a threshold of 95% contribution towards the endpoint indicators (fig. 3). For each endpoint, only one or two midpoint indicators were required to reach 95% accuracy. Assuming all endpoint indicators are equally important, the relevant midpoint indicators were, in sequence of contribution: (1) Photochemical Ozone Formation, (2) Climate Change, (3) Fossil Depletion and (4) Fine Particulate Matter. In previous tenders, only Climate Change and Metal Depletion were included. Interestingly, this perspective proved to be incomplete, as three of the four most dominant indicators are not even considered in previous tenders (POF, FD and FPM).

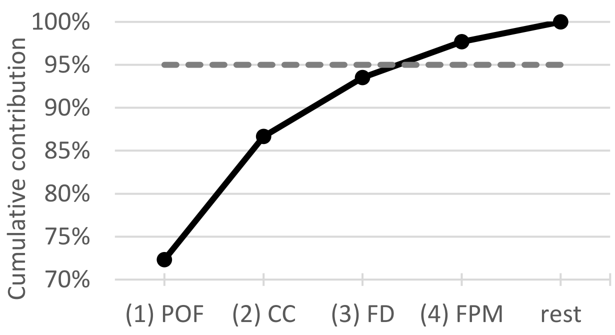

Fig. 3: Midpoint indicator contribution towards endpoint score in the case study (based on ReCiPe 2016)

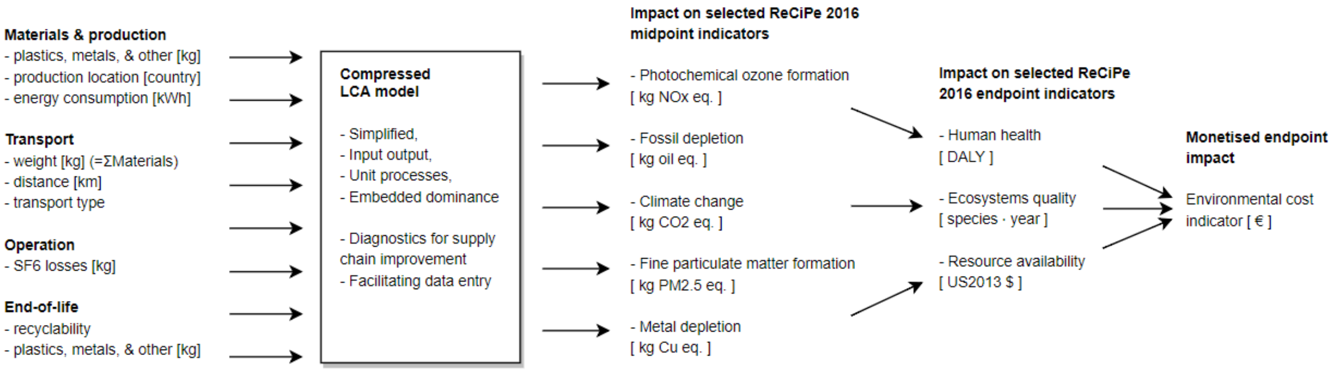

Fig. 4: Image of simplified LCA black box for switchgear - including concrete inputs and outputs

Input simplification

After establishing an inventory containing all relevant processes, materials and energy of the full LCA, the simplification process was initiated. This was done by evaluating which life cycle phases have a significant contribution to the eventual impact. This is done for the raw materials, production, transport, operation, and end-of-life phases. The transport phase was the least dominant phase. However, there was a large variance in the type of transport and the production location. So, in some cases it did account for a contribution of up to 10%. With this, it was concluded that no life cycle phase can be excluded before-hand. For each of the phases a number of critical parameters were set-up in a spreadsheet model. Filling the spreadsheet model was facilitated by providing the required level of significance and industry standard values. This way it is easier for Liander to detect anomalies. The unit process data was taken from dedicated LCA databases (e.g. ecoinvent v3 and Thinkstep database), complemented by industry data (e.g. from Eurofer, Worldsteel, and PlasticsEurope).

Monetization

Monetization was done in the case study for the three endpoint indicators of the ReCiPe 2016 IAM: damage to human health (years of human life lost in DALY's), damage to ecosystems quality (loss of biodiversity in species·years), and damage to resource availability (surplus costs of future extraction in US$), were all expressed in $€_{2018}$. The damage to human health was monetized based on the internal valuation of loss of human life, as used in Liander's risk management. For the damage to ecosystems, no internal valuation currently exists at Liander. So, a monetization factor was adopted as proposed by Weidema [9], based on a budget constraint method, which determines the willingness to pay for ecosystems quality at a certain area. The damage to resource availability is already monetized, and can be rewritten in the relevant currency. The constructed monetization values were cross-referenced to scientific literature and independent policy advises.

Integration in procurement process

The results from the case study are compared to the results from a previous tender (the source of the historical data).

Weight

The average environmental burden in the case study was circa €4.400, the difference between the worst supplier in terms of environmental impact was circa €2.300, and the products in this lot of the tender have a price level of circa €10.000. This means that in the case study environmental impact would be considered at 23% relative to the TCO. The financial criterion had weight of 50 %. So, depending on the actual price environmental burden, when the approach of this thesis would have been used, the environmental impact would have a weight of 11,5 %. In the actual tender, sustainability had a weight of 10 %.

Scoring

When comparing the assessed sustainability with the actual tender (see Table), interesting differences emerge. The suppliers with the two best scores on sustainability are reversed in the case study. The same holds true for the 4th and 5th place. Furthermore, whereas the difference between Supplier C and D received the same score in the actual tender, there is a large difference between them in the hypothetical case study. So, with an LCA-based environmental assessment, another supplier would receive the highest score for environmental impact. Other decision criteria are not considered in this comparison, and the actual tender was for dual sourcing, so the actual contracts would likely remain the same. However, more insight is gained in the actual impact of the suppliers.

Table 1 - Comparison between sustainability score in the actual tender and case study

Supplier	Actual tender score	Case study environmental burden (monetized)	Case study score (normalized)
A	10.0 (1st)	€3.635	8.2 (2nd)
B	6.5 (2nd)	€3.230	10.0 (1st)
C	3.7 (3rd)	€4.370	5.0 (3rd)
D	3.7 (4th)	€5.505	0.0 (5th)
E	1.8 (5th)	€5.105	1.8 (4th)

CONCLUSION

In order to achieve the objective of this research while adhering to the aforementioned design criteria, two main design challenges were tackled. The first challenge consists of streamlining LCA so it becomes practically usable to be considered in Liander's procurement processes. This challenge was tackled by only including the most dominant material & energy flows in the LCI phase as well as only including the most dominant midpoint effects when presenting the outcome of the LCA. Based on a full LCA, this focused reduction in scope significantly simplifies the LCA process for future use, while still retaining a high degree of validity. The streamlined approach, as demonstrated in the case study, retained a validity of at least 95% while reducing the LCI stage to only 11 input parameters and 4 midpoint effects. Interestingly, two of these four midpoint effects were previously overlooked. Moreover, it was discovered that an unconsidered indicator was the most dominant one.

The second challenge was to integrate the streamlined LCA approach into the procurement processes so they could be assessed alongside other criteria, such as LCC and asset performance. This can be achieved by monetizing the environmental impact profile and subsequently treating its impact similarly to the DSO's expected TCO. It was shown that using streamlined LCA only resulted in minor differences in the sustainability score of the suppliers. As the case study neglected the other decision criteria, and it was a dual sourcing tender, this would not likely influence the actual tender outcome.

The presented approach to streamlined LCA proved to be able to provide a mostly valid, yet easy-to-use insight into the environmental impact of an asset during the tendering processes. This result contradicts the commonly held belief that LCA is too complex and tedious to be reasonably considered in asset procurement. This outcome offers an opportunity for DSO's and manufacturers to take responsibility and break out of the catch-22 situation where manufacturers have few environmentally friendly assets to offer because DSO's are not including these factors when evaluating their asset acquisition decisions.

RECOMMENDATIONS

The approach for streamlining LCA does require at least one comprehensive LCA study to be performed, requiring an initial investment in resources or expertise to be used, though this process can also be outsourced. Even though the method presented in this paper was demonstrated using the procurement process of switchgear, it can also be applied to other asset types. DSO's also generally manage a large number of technically similar assets in asset portfolios. Instead of needing to develop comprehensive LCA's for each asset individually, they can also be performed on an "archetypical" asset, representing a typical example of an entire asset portfolio. This archetypical "master" LCA can then be quickly re-used for various other purposes with little effort, such as life cycle planning or future tenders. Practitioners should be aware that the simplification is only valid as long as the goal and scope definitions of the LCA do not change.

LIMITATIONS

Design Science Research calls for demonstration in context. However, actual implementation using a real-world case study did not fit the timeframe of the research project. The method will be applied in an upcoming tender at Liander. Based on the results from this tender, the method will be improved and applied in the future in a continuous iterative learning cycle.

Another limitation is that the proposed method only works for IAM's that use mid- & endpoint effects, such as the ReCiPe IAM. Though it is conceptually possible to establish midpoint effect dominance based on normalized results, this would introduce new procedural challenges influencing the validity of the LCA results.

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