Int J Life Cycle Assess (2011) 16:178–186
DOI 10.1007/s11367-011-0253-2

POLICIES AND SUPPORT IN RELATION TO LCA

Environmental life cycle assessment as a tool for identification and assessment of environmental aspects in environmental management systems (EMS) part 1: methodology

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Received: 28 January 2010 / Accepted: 18 January 2011 / Published online: 8 February 2011

Abstract
Purpose The paper presents a discussion on the possibilities of using life cycle assessment (LCA) in identification and assessment of environmental aspects in environmental management systems based on the requirements of the international ISO14001 standard and the European Union EMAS regulation. Some modifications of LCA methodology are proposed in part 1, while the results of a review of environmental aspects for 36 organisations with implemented environmental management systems (EMS) are presented in part 2 of the article.
Materials and methods The scope of the systems analysed in EMS and in LCA is different. This comes as the result of the fact that both ISO 14001 and EMAS are focused on an organisation contrary to ISO14040x, which are focused on a product life cycle. For the present work, this resulted in a need of adjusting the LCA methodology to EMS specificity, and vice versa. Some suggestions of such modifications are presented and discussed in the paper.
Results A preliminary analysis was carried out on 36 organisations, which have EMS compliant with the ISO14001 or EMAS regulations. It has found a certain disproportion between input and output-related environmental aspects included in most of the analysed registers. The probable reasons for such disproportion could be the fact that the output-related environmental aspects are easier to manage by organisation and are often regulated by laws. Legal requirements are a significant criterion in the environmental aspects assessment.
Discussion Based on the assessments carried out and the observations made, some conclusions have been drawn with regard to weaknesses and strengths and usefulness of LCA, as a result of a comparison to the traditional approaches used in EMS in the discussed area. LCA has evident advantages like: standardised methodology; possibility of inclusion of the quantitative information; presence of some methodological steps enabling the verification of the collected data; ability to generate of reproducible results. At the same time, the following potential weak points can be observed: a complexity of the procedure; higher time and cost requirements (especially related to an inventory phase); difficulties with assessing of environmental aspects with the qualitative character and these related to emergency situations; limitation related to the lack of relevant characterisation factors in the currently used LCIA methods.
Conclusions LCA ought to be considered as a tool used for identification and assessment of environmental aspects in EMS. The listed limitations do not disqualify its suitability to be used. After certain simplifications, LCA seems to be a valuable alternative to the methodologies currently in use.

Keywords Assessment · EMS · Environmental aspects · Identification · LCA

1 Introduction

There are various areas in which life cycle assessment (LCA) can be used, from macro-scale sector analyses or uses within the public sector, to individual organisations, including mainly ecodesign and environmental products

Responsible editor: David Pennington

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declarations. One of the micro-scale areas that is relatively, briefly explored is the use of LCA in environmental management systems (EMS). ISO14040 directly indicates the possibility of using LCA as part of EMS in order to evaluate environmental performance and also as a tool for identification of significant environmental aspects of products and services of an organisation (ISO 14044:2006). The two parts of this article (part 1 and part 2) discuss and present results of analyses carried out in order to establish the usefulness of LCA in EMS compliant with ISO14001 and EMAS. Moreover, an attempt has been made to identify weaknesses and strengths of LCA in this area of use, especially in the light of the requirements relating to the environmental performance's indicators (Jasch 2000; Hermann et al. 2007; Gernuks et al. 2007). The observations made in the presenting study are mostly coincident with these obtained by (Zobel et al. 2002); however, in our study, a starting point was an appraisal of LCA in the light of ISO 14001 and EMAS guidelines and a comparison to the traditional approaches used for identifying and assessing the environmental aspects in EMS.

2 LCA in the context of recommendations for methodologies used for identification and assessment of environmental aspects in EMS

The process of identification and assessment of environmental aspects is the key element of the ESM of an organisation (Zobel and Burman 2004). An environmental aspect is defined as an element of an organisation's activities or products or services that can interact with the environment (ISO 14001:2004). An aspect regarded significant is the one that has or can have a significant environmental impact. Both identification and assessment of aspects are the elements included in a planning stage of EMS and are most often carried out already during a preliminary environmental review (Matuszak-Flejszman 2007). For instance, environmental aspects include emissions, consumption or reusing of materials, or noise emissions. An organisation implementing EMS should identify these environmental aspects, which it can control and over which it can have an influence. The company should develop and maintain a procedure to identify and assess the environmental aspects. The reviews of environmental aspects need to be recorded and maintained as part of the EMS documentation system (Stowe 2001). Even if employees (of an organisation) in charge of identifying environmental aspects assume that they have identified all of them, the process must be started when, for example, an organisation modifies some of its operations or processes or changes its EMS (Zobel and Burman 2004; Lundberg et al. 2007). So the processes of identification and assessment of environmental aspects should be repeated regularly, in order to adjust the system to the changing conditions in which an organisation operates. The goals, tasks, and environmental programmes, which are fundamentals of EMS are prepared based on selected significant environmental aspects. The documents regarding EMS compliant with ISO 14001, ISO14004, and EMAS do not clearly identify the way in which the environmental aspects should be identified or assessed (Matuszak-Flejszman 2007). ISO 14004 states: there is no single approach for identifying environmental aspects and environmental impacts and determining significance that will suit all organizations (…) (ISO 14004:2004).

Taking into account the considered usage, an assumption can be made that the methodology used in identifying and assessment of aspects should, above all, meet two criteria: enable the identification of aspects related to the operations of an organisation and offer a procedure of assessing the impact in order to identify significant aspects. Taking into account these two preliminary criteria, LCA can be recommended as a potential tool for this area of usage. LCA, in accordance with ISO 14040, deals with environmental aspects and possible impacts on the environment and as such it includes both of the considered elements. A separate issue, discussed in point 3 of this article, is the problem of adjusting the LCA methodology to a different scope of the systems analysed in EMS, this comes as the result of the fact that both ISO 14001 and 14004 are focused on an organisation contrary to ISO14040x, which are focused on a product life cycle. ISO 14004, even though it does not regulate the way in which aspects are identified and assessed, it does, however, provide a range of recommended features which should characterise such a procedure. Table 1 describes these recommendations, and a LCA carried out in its context.

The data presented in Table 1 show that LCA fits well in the general guidelines recommended for identifying and assessment of environmental aspects. It seems that the most disputable point is some generality of impact modelling in life cycle impact assessment (LCIA). LCA, as per its definition, defines potential impacts on the environment and is not used for detailed impact modelling, in contrary to, e.g. risk assessment or environmental impact assessment (EIA), which are used for operating permits and other location-related decisions (Guinee et al. 2002). What should be taken into account is how significant this fact is for using LCA in the discussed area and whether it can disqualify this technique. The analysis of methodologies used for identifying and assessing environmental aspects (eg. brain-storming, screening processes, inspections, analysing process-by-process, environmental aspects grip, point estimation method or ABC analysis) (Byggeth and Hochschorner 2006; Gajdzik 2006; Gajdzik and Wycislik 2007; Matuszak-Flejszman 2007; da Silva and Amaral 2009; Stowe 2001)

Table 1 LCA in the light of ISO14004 recommendations (ISO 14004:2004)

ISO 14004 Recommendations	Level at which LCA meets the recommendation (+, ++, +++) + low compatibility +++ high compatibility	Comments
Recognition of both positive and negative environmental impacts	+++	LCA enables both quantitative and qualitative identification of environmental impacts of both positive and negative character, with a strong focus on the latter ones
Identification of actual and potential environmental impacts	++	Full time and space integration is a default simplification included in life cycle impact assessment, what results in focusing on potential rather than actual impacts. However, in the recent years, a lot of efforts on developing spatially specific equivalency factors have been made to reduce the generality of LCIA (Guinee et al. 2002)
Identification of elements of the environment which can be affected	+++	Data collected for LCA assessment deal in detail with environmental aspects related to various areas of the operations of an organisation (production, warehousing, transport, etc.) and environmental elements (air, water, soil)
Taking into account the local features to which impacts can relate	+	The local and regional features can be taken into account in life cycle inventory, and in a limited extent, also in life cycle impact assessment
Recognition of the nature of changes in the environment	+++	LCA includes impact categories on a global scale (climate changes, ozone layer depletion) as well as on a regional or even local scale (acidification, eutrophocation, photochemical oxidation). Various temporal horizons of impact modelling enable to recognise the phenomenon of impact accumulation in time

enables the statement that in practice, it is not generally common to use methodologies with a developed and advanced EIA. The used methodologies are of semi-quantitative and qualitative character, not based on any impact models. A cause and effect definition between aspect and impact is usually made in a generic and descriptive way, based on the knowledge and experience of an environmental manager and the members of a cross-functional team involved in implementing EMS (which can, but not necessarily must be, specialists in environmental impact modelling). Even if taking into account the specific conditions of an aspect being born (e.g. emission conditions), then they are still subject to a general verification, not supported by a standardized and scientifically accepted methodology. It seems then that the generality of LCIA is not any limitation, and it does not disqualify this tool in identifying and assessing aspects in EMS. Additionally, LCA meets well or very well all the other guidelines formulated within ISO14004.

3 The impact on the structure of LCA as the result of using the methodology in EMS

EMS, like LCA, are designed for and implemented in various types of organisations with various types of activity, size, technology advancement, market position and various motivations for proecological activity. That is why both EMS compliant with ISO14001 and EMAS, as well as LCA, ought to show some flexibility. Depending on the assumed goal and use, various types of LCA with various levels of detail and advancement are carried out. The main question is, therefore, to what extent LCA methodology could be used for identifying and assessing environmental aspects. The relation between elements of LCA methodology and identification and assessment of aspects in EMS is presented in Table 2, where each step of LCA methodology (column 1) is discussed in the context of its conformity to the current routines used in EMS (column 2) and in the light of a potential need for its implementation (column 3) in the specific area of EMS (column 4). If the element is recognized as present in the current EMS practices (e.g. goal of the analysis), it does not require any implementation in any area of EMS.

3.1 Identification of environmental aspects with the use of LCA

The aspects identification procedure should lead to selection of as many elements of an organisation's operations which potentially can react with the environment as possible. Moreover, in order to retain the coherency in the planning stage, it should be possible to cover the identified aspects with a common assessment procedure. When discussing the use of LCA for this purpose, it has to be mentioned that in order to enable assessment of aspects, they should be of quantitative character and should be captured in a way suitable for LCA analyses. Based on the data in Table 2, the identification stage of environmental aspects in EMS is included mainly in

Table 2 LCA methodology in the context of EMS

1		2	3	4	5
LCA phase		Presence in EMS yes/no/possible	Implementation from LCA to EMS yes/no/possible	Area of use in EMS	Comments
Goal and scope definition	Goal of analysis	Yes	No		The goal is identified within EMS (in a more or less similar way as it happens in LCA), so it does not need any special implementation (Zobel et al. 2002;)
	Application	Yes	No	–	Each of th environmental management system has at its goal, the realisation of continuous improvement of an organisation, so as per the definition of EMS, the possible use of LCA shall be focused on internal goals of an organisation
	Stakeholders	Yes	No	–	Communication with stakeholders is an important element of EMS, playing an even more important role than in LCA
	Product system including a breakdown into unit processes	Possible	Yes	Aspects identification	Recommended to adjust LCA to the specificity and scope focused on an organisation. The breakdown into each area of an organisation's operations as a breakdown into unit processes.
	Function of the system	No	Possible	Aspects identification	Recommended to set up the identification of aspects with regard to the function defined by the operations of an organisation
	Functional unit	No	Yes	Aspects identification	In order to coherently collect and calculate the data, it is recommended that a functional unit with regard to e.g. annual production is introduced
	Product system boundaries	Yes	No	Aspects identification	The system boundaries are defined in EMS, even though they do get modified after introduction of the life cycle perspective
	Data requirements	Yes	Possible	Aspects identification	Possible to introduce requirements and assessment of data quality in EMS. This would make the results more credible.
Life Cycle Inventory	Preparation and collection of data	Yes	No	Aspects identification	Recommended to adjust EMS to LCA methodology within this area
	Data validation	Possible	Yes (if not used)	Aspects identification	If not present in EMS, it is recommended to adjust to LCA methodology within this area
	Assigning of data to unit processes	Possible	Yes (if not used)	Aspects identification	If not present in EMS, it is recommended to adjust to LCA methodology within this area
	Assigning of data to functional unit	No	Yes	Aspects identification	Recommended to adjust EMS to LCA methodology within this area
	Allocation and allocation procedure	No	Yes	Aspects identification	Recommended to adjust EMS to LCA methodology within this area
Life Cycle Impact Assessment	Choice of impact category, category indicators and characterising models	No	Yes	Aspects assessment	Recommended to adjust EMS to LCA methodology within this area
	Classification	No	Yes	Aspects assessment	Recommended to adjust EMS to LCA methodology within this area
	Characterisation	No	Yes	Aspects assessment	Recommended to adjust EMS to LCA methodology within this area
	Groupping	No	Possible	Aspects assessment	Recommended to adjust EMS to LCA methodology within this area
	Normalisation	No	Possible	Aspects assessment	Recommended to adjust EMS to LCA methodology within this area
	Weighing	No	Possible	Aspects assessment	Recommended to adjust EMS to LCA methodology within this area

Interpretation	Data quality assessment (LCI and LCIA)	No	Possible	Aspects identification and assessment	Possible to introduce requirements and assessment of data quality in EMS. This would make the results more credible
	Identification of significant issues	No	Yes	Aspects assessment	Significant element, enabling understanding and interpretation of results
	Coherency analysis	No	Possible	Aspects identification and assessment	Possible to introduce to EMS as an interpretation element
	Uncertainty analysis	No	Possible	Aspects identification and assessment	Possible to introduce to EMS as an interpretation element
	Sensitivity analysis	No	Possible	Aspects identification and assessment	Possible to introduce to EMS as an interpretation element

the phases 1 and 2 of LCA. It comes as a reflection of the fact that aspects are identified with environmental interventions and LCI data. EMS identifies aspects related to past, current and planned operations of an organisation. It does not, however, seem to be an issue from the point of view of LCA, taking into account that these assessments can be of retrospective or prospective character. As per ISO 14001 and 14004, aspects which are subject to identification related to normal, special and emergency conditions of an organisation's operations. Partly and nondirectly, these elements are usually included in LCA, e.g. consequences of equipment defects and their repairs, production downtime related to changeover or restarting of production line etc. There are, however, aspects which are typical for EMS, which traditionally are not mentioned in LCA, e.g. sudden accidents and fires.

It is possible to capture elements related to normal and special conditions. It seems, however, problematic to do so with emergency situations (often bearing a high environmental risk). The main barrier seems to be the ability to express these aspects in a quantitative way. Even if they could be estimated, the results will bear significant uncertainty. A good example is a fire occurring in an emergency situation. Sample environmental aspects occurring in this case include: emissions to air, water and soil as well as waste. A qualitative identification of these among the aspects is possible and practiced. However, in order to include these elements in an assessment of impact compliant with LCIA methodology, they should be assigned as specific values, which seems problematic from many points of view. First of all, to assess the type and content of emission and waste, we would have to specifically describe what had been affected by the fire, since the combustion and decomposition products depend on the type of the material that had been burnt. Moreover, the quantity of the material, which had been damaged, should be identified, and a breakdown into various environmental media into which the substances are emitted should be made. It is possible to create scenarios like this, based on the structure and type of the used materials and the operations of an organisation; however, the results will always bear high uncertainty. In theory, it would be possible to base it on historical data. However, emergency situations do not seem to be of repetitive or cyclical character (contrary to normal and special conditions), so historical data might not be found useful. It seems that within the identification stage, it should be the priority to strive to identify the most number of aspects. The lack of possibility of expressing them in a quantitative way will surely make it impossible at a later stage for them to be assessed with the use of LCIA. It cannot be, however, treated as a disqualifying factor with regard to identification stage, because that way an organisation might omit significant or even key environmental issues. In the

light of the above, all efforts must be made in order to collect quantitative data, because it will make the information based on LCA more complete. In the process of identification, it would be valuable to use some of the elements compliant with LCA methodology. The analyses carried out by the authors show the use of a functional unit beneficial as it combines two criteria of aspects assessments: frequency and quantity.

Moreover, aspects might include such issues, which are usually omitted in EMS, like land use and transformation (not limited to special or emergency conditions, but also used in normal operations), identifying of transport factors, taking into account the recycling and waste management in the process of the final disposal (not limited to waste management within an organisation).

A significant issue, from the point of view of identifying aspects, is focusing attention in LCA on breaking the system down into unit processes. In environment management systems, such a divide operates to some stage. When scrutinising ISO 14004 guidelines, it looks like the areas where it is recommended to identify aspects, are not only those geographically correlated with an organisation (design and development, production processes, packaging, transport, waste management, natural environment and biodiversity) but also the ones which are beyond its boundaries: the effects of the environmental policies and practices of manufacturers and suppliers, extraction and distribution of raw materials and natural resources, distribution, use and waste management. From this point of view, a distinction between direct and indirect environmental aspects is important. Direct environmental aspects are associated with activities, products and services of the organisation itself over which it has direct management control and they can be controlled by internal management decisions (EMAS guidance document 06). Indirect aspects concern the actual or potential activities over which the organisation can be expected to have an influence, but no control. If use LCA in EMS, identifying and capturing the "ecological burdens" related to both indirect, as well as direct aspects, can be possible, which has the key meaning especially in EMAS.

Likewise, a general division into input and output-related environmental aspects could be helpful. LCA is input–output analysis, which strongly determines a mode of conducting and organizing a study (data collection, model validation, interpretation of the results). Meanwhile in EMS, input–output thinking is not obvious, rather intuitional, and without clear methodological implications. The input-related aspects include as well as input elementary flows (land occupation, deposits of fossil fuels and metal ores, oxygen from air) and inputs from technosphere (electricity, plastics, petrol). Similarly, output-related aspects embrace output elementary flows (emissions to the air, water and soil) and outputs to the technosphere (products, waste for treatment). The set up with regard to inputs and outputs of aspects identification procedure would enable balancing of data and verifying the correctness and completeness of a model. In any of the analysed registers, the input and output-related aspects could not be balanced because of omitting the elements related to them, which traditionally would be taken into account in LCA (e.g. use of fuel in transport processes requires collecting of data with regard to air use, emission and wastage).

Another issue, which ought to be considered, is the quality of data. In LCA, contrary to EMS, different techniques for estimating and expressing data quality and uncertainties are available (Huijbregts et al. 2001; Ciroth 2004). It seems that using this experience in EMS would be valuable. Since using LCA to carry out this assessment would increase the requirements with regard to time and the complexity of the procedure, it seems that other compromise solutions ought to be sought. Since the implementation of EMS compliant with ISO 14001 and EMAS guidelines is an internal decision of an organisation and it contributes to its internal improvements, there is no need to impose such high requirements, which function, e.g. with regard to the comparative assertions disclosed to the public. It seems to be recommended therefore to use some simplification by dividing the analysed system into two subsystems: foreground and background (Guinee et al. 2002). The primary data could be collected then for the foreground processes referred to direct environmental aspects, while all indirect environmental aspects could be treated as background processes with a possibility of using secondary data. As a consequence, the data collected within an organisation would be characterised by the highest quality (spatial, temporal and technological), and the data regarding indirect aspects could be generic, subject to thorough verification. When confronted with qualitative or semi-quantitative methods which are usually practiced, the uncertainty brought this way should not be higher. Carrying out of identification and assessment of aspects with the use of LCA requires more time and effort as the collected data is more detailed. To sum up, from the point of view of the environmental aspects identification stage, LCA can be used in this area but requires the above-described modification.

3.2 Environmental aspects assessment

The second, not less significant stage, is the assessment of identified environmental aspects. In accordance with ISO14004, it is advised that the following assessment criteria are followed:

- environmental criteria,
- legal regulations,
- internal and external issues regarding the stakeholders.

Table 3 LCA in the context of environmental criterion used to assess the environmental aspects

Features	Presence in LCA	Comments
Impact scale	Yes	LCA includes both global and regional environmental issues. The results of an indicator with regard to each impact category inform about generating impact within the range of each environmental issue with a specific scale
Impact severity	Yes	The severity of impact related to aspect (LCI data) is expressed directly by the value of characterisation factors
Impact duration	Yes, indirectly	The duration of impact is possible to be expressed by carrying out the modelling of impact for various temporal horizons
Aspect type	Yes	The complexity of LCA enables capturing and assessing of a variety of aspects (natural resources, very wide range of ready products, emissions to air, water and soil, waste management)
Aspect size	Yes	The size of aspect (quantity) expressed in the assessment based on a functional unit, e.g. 2,000 L to indicate the use of diesel in transport operations for the 2008 annual production
Frequency of aspect	Yes	The frequency based on a functional unit, e.g. if functional unit is expressed as annual production in 2008 and aspect is expressed as the use of toners with the frequency of use 10 toners per 2 years, then the aspect value equals 5 toners (all aspects are calculated with regard to functional unit)

The criteria regarding assigning of meaning to environmental aspects can be used for both environmental aspects of an organisation, as well as related to them, impacts on the environment. The environmental criteria can be used for both environmental aspects and impacts, but majority of them find use in the latter.

Whilst developing the criteria, an organisation can set levels (or values) of meaning with regard to each criterion, e.g. based on the possible combinations of contribution (probability/frequency) and its consequences (seriousness and intensity). Some types of ranking scales can be helpful in describing a meaning, e.g. quantitatively with regard to numeric values or qualitatively with regard to levels like high, medium, low or non-significant. The considered use of LCA for assessment of aspects is with regard to environmental criterion. Assuming that all the criteria used by an organisation belong to the same point scale, then the results obtained based on LCA should be correlated with the accepted system of scoring and should enable the assessment of aspects while taking into account all the remaining indicators. Within the environmental criterion, the following ISO 14004 features are mentioned: scale, severity, duration of impact or type, size and frequency of environmental aspect. Table 3 shows the evaluation of LCA with regard to these guidelines.

Further to the information presented in Table 3, LCA meets all the requirements aimed at methodologies used in aspects assessments with regard to the environmental criterion. This stage is the equivalent to phase 3 in LCA analysis—life cycle impact assessment. LCA offers in this case a normalised and scientifically accepted methodology, offering a possibility to get repetitive results. With regard to the LCIA methodologies which are practiced, there are characterisation factors for a variety of environmental aspects, which are calculated based on an advanced modelling (fate analysis, exposure, effects and damage analysis). When confronted with the descriptive and qualitative methodologies used usually in EMS, it undoubtedly has advantages. With regards to the practiced procedures, environmental compartments affected by potential impact (air, water, soil) are taken into account, and the relation between aspect and environmental issues (climate change, aciditification, eutrophication) are made. It is however done in a descriptive and qualitative way concluded with a semi-quantitative scoring system. As mentioned previously, what seems to be an issue and somewhat a limitation in the use of LCA is qualitative aspects.

On one hand, they are the previously described issues related to emergency situation; on the other hand, however, are the strictly qualitative issues, e.g. planning and administrative decisions, the danger of serious environmental catastrophes or operations of a third party on an organisation's premises. When practicing LCA regularly, some of the results of LCI cannot be measured by the impact assessment (qualitative character, lack of environmental data in LCIA). Such cases should be clearly documented and their contribution in creating the impact should be described. There is a risk (as in every case of LCA) that in the currently available LCIA and databases, there will be no relevant information regarding some of the identified

Table 4 The assessment of aspects significance based on the results of the contribution analysis

Contribution of the aspect in the overall impact [%]	Significance of the aspect	Number of points
Contribution >50%	Most significant	3
25%<Contribution<50%	Significant	2
10%<Udz contribution iał<25%	Some impact	1
2.5%<Contribution<10%	Little impact	1
Contribution<2.5%	Negligible impact	0

Table 5 The results of LCA combined with the aspect assessment based on the remaining criteria

	Legal regulations [points]	Stakeholders [points]	Environmental criterion		Total score [points]	Assessment result
			Results of the contribution analyses [%]	Environment [points]		
Aspect 1	0	0	3	1	2	–
Aspect 2	1	1	15	1	3	–
Aspect 3	0	1	38	2	3	Significant
Aspect 4	1	3	20	1	5	Significant
Aspect 5	2	2	12	1	5	Significant
Aspect 6	2	1	12	1	4	Significant
Significant=> 3 points						

aspects. In that case, even if the aspect has been expressed in a quantitative way, it will not be taken into account in LCIA calculations.

As previously mentioned, EMS contribute to internal improvements of an organisation. In that case, using LCA would be on a micro-scale and would have internal character. Moreover, in this use, the assessments are not comparative, since they include changes in time made with regard to one system (organisation). Therefore, it seems possible to use the weighing scores of LCIA and making decision on the single score level. What is more, such a solution towards the whole complexity of the procedure, time consumption with regard to gathering the data, ought to be recommended.

In the aspects assessment, also other criteria like legal requirements and relations with stakeholders are taken into consideration. The semi-quantitative methodologies used in practice are simple and easy solutions, which enable the assessment of all of the identified aspects with regard to the set criteria. If we were to use LCA in assessing aspects within the environmental criterion, then the obtained results should be integrated with the analysis carried out with the use of remaining criteria. We could therefore ask a question—how should LCIA results be classified and combined with the points rating.

In order to do that, the use of classification recommended in ISO 14044 with regard to the contribution analysis could be recommended. A presented proposal includes five ranges to which points can be assigned depending on the point scale used by an organisation to assess the environmental aspects (Table 4).

For example, taking into account that the assessment covers six of the identified aspects, and the base for the assessment are three criteria: legal requirements, stakeholders and environmental criterion, the results of the assessment with the use of LCA are shown in Table 5.

Table 6 Weaknesses and strengths of LCA with regard to using it in EMS

Strengths		Weaknesses	
Aspects complexity	Including direct and indirect aspects with a divide into various types: input and output elementary flows, inputs and outputs to/from technosphere	Time consumption and cost of analysis	A larger number of aspects taken into account causes higher requirements with regard to data (both quantity, detail). The need of purchasing software and training of employees increases the cost
Environmental problems complexity	Several impact categories including environmental issues on a global, regional and local scale	Analysis complexity	LCA is more difficult than analysing the aspects with the use of traditional methodologies
Known, standardized and scientifically based methodology	Availability of norms, manuals, software supporting the assessment process. The agreed methodology with regard to all stages of LCA, and therefore including identification and assessment of the aspects	Not possible to include quantitative aspects	Aspects not expressed in a quantitative way cannot be included in a qualitative impact assessment
Results repetitiveness	While adhering to a strict procedure, LCA give repetitive and reproducible results	Potential problems in case of emergency situations	Including aspects related to emergency situations seems very difficult. Even if assumptions and estimates are made, the results for these aspects will be burdened with large uncertainty.
Quantitative approach	Both aspects and impact assessment results are of a quantitative character		

In presented case, the scale 0–3 has been agreed (where 0, nonsignificant; 3, very significant) and it has been assumed, that the aspect will be regarded as significant if the total sum of the points for all the criteria will equal to or is more than 3., It is worth mentioning that in EMS practice, every organisation might decide on the rules of the aspects assessment and the assessment criteria can differ from case to case.

4 Conclusions

The environmental life cycle assessment, in the context of being used for identification and assessment of environmental aspects in EMS, has advantages but also has its limitations (Table 6). The main weaknesses, from the point of view of the considered application, included higher time consumption, cost and the complexity of the assessment (Baratto et al. 2005; Millet et al. 2007; Lee et al. 2009) in comparison to the traditional approach. Moreover, when using LCA it is not possible to identify the quantitative impact on the environment for the qualitative aspects (including the quantitative identification in emergency situations).

On the other hand, however, LCA enables a number of possibilities like, e.g. the complex capturing of indirect aspects and related to them in a way impacts on the environment, the presence of a standardized methodology with regard to every stage of the assessment and the opportunity of obtaining repetitive and quantitative results.

To sum up, LCA ought to be considered as a tool used for identification and assessment of environmental aspects in EMS. The listed limitations do not disqualify its suitability to be used. With relevant financial and manpower resources, LCA seems to be a valuable alternative to the methodologies currently in use. Taking into account the fact that the identification and assessment of the environmental aspects is carried out regularly and systematically, the most cost would be borne when carrying out the first ever assessment, when there is a requirement of purchasing software and training of the employees.

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