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Chapter 7 Social Life Cycle Assessment

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Abstract In this chapter, after a brief literature review, the social life cycle assessment (S-LCA) technology is introduced, including fundamental terminologies, steps for Implementing an S-LCA, and seven major assessment methods. A case study is presented to illustrate how the procedure and relevant assessment methods are applied in the S-LCA of a company producing lighting products.

Keywords: Life cycle assessment, LCA, Social life cycle assessment, S-LCA, Life cycle impact assessment, Impact assessment methods, Performance reference points, Lighting products

Table of Contents

7.1 Introduction.....	2
7.2. Fundamentals.....	3
7.3. Steps for Implementing S-LCA	3
7.3.1 Definition of Goal and Scope, System Boundaries and Functional Unit	3
7.3.2 Life Cycle Inventory Analysis	3
7.3.3 Life Cycle Impact Assessment.....	4
7.3.4 Life Cycle Impact Interpretation	4
7.4. Main Assessment Methods for S-LCA.....	4
7.4.1 Performance Reference Point Method	4
7.4.2 Impact Pathway Method	5
7.4.3 Checklist Method.....	5
7.4.4 Scoring Method	6
7.4.5 Database Method	6
7.4.6 Empirical Method	7
7.4.7 Environmental Life Cycle Inventory Database Method	7
7.5. Case Study	7
7.5.1 The schematic and rating scale.....	7
7.5.2 Life Cycle Inventory Analysis	13
7.5.2.1 Workers	13

7.5.2.2 Consumer	14
7.5.2.3 Society	15
7.5.3 Comments on the Assessment Results	16
7.6. Concluding Remarks.....	16
Acknowledgment	16
References.....	16
Appendix 7.1 List of Performance Reference Points (Ciroth and Franze, 2011).....	19

7.1 Introduction

The early work in social life cycle assessment (S-LCA) was reported by Fava et al (1993) which was about the society and social-economic impacts within the life cycle framework discussed at the workshop 'A Conceptual Framework for Life Cycle Impact Assessment' hosted by the United States Environmental Protection Agency. This report proposed a concept of social life well-being category, investigated the direct and indirect environmental impacts caused by the society, and included the society impacts were into the framework of product life cycle environmental evaluation.

In the early of 2000, scholars proposed the framework for evaluating social impacts through life cycle, and the damage categories, impact categories, category indicators and inventory data for the evaluation framework (Weidema, 2006; Dreyer, Hauschild and Schierbeck, 2006; Benoît *et al.*, 2007). Additionally, the method was introduced for the social life cycle evaluation and challenges related to the framework (Labuschagne and Brent, 2006; Hunkeler, 2006;Jørgensen *et al.*, 2008).

In order to promote the implementation for social life cycle impact assessments, the United Nations Environment Programme (UNEP) and the Society of Environmental Toxicology and Chemistry (SETAC) developed 'Guidelines for Social Life Cycle Assessment of Products' (Benoît *et al.*, 2009). The Guidelines give the definition of social LCA as 'a social impact (and potential impact) assessment technique that aims to assess the social and socio-economic aspects of products and their potential positive and negative impacts along their life cycle encompassing extraction and processing of raw materials; manufacturing; distribution; use; re-use; maintenance; recycling; and final disposal'. The guidelines also state that social LCA complements environmental LCA with social and socio-economic aspects. It can either be applied on its own or in combination with E-LCA. The Guidelines explain the rationale regarding the society impacts for products and provide a solid social impact evaluation framework.

There are several assessment methods developed by researchers for S-LCA. Benoît (2010) introduced two types of methods: (1) to select or create the impact categories based on the stakeholders' interests in social aspects, and to use the combined results of subcategories as the evaluation results of the impact categories; (2) to model the pathway from subcategory to impact category, and fill the evidence to evaluate the performance of the impact category and subcategory. Chhipi-Shrestha et.al. (2015) defined 'performance reference point methods' and 'impact pathways methods'. The performance reference point methods assesse social impacts using performance reference points based on internationally accepted minimum performance levels such as ILO1 conventions (Pörtl and Spiegel, 2014) and ISO 26000 guidelines (ISO, 2010). The impact pathways methods assesse the social impacts of a product system using impact pathways as characterization models comprised of midpoint indicators and/or endpoint indicators similar to environmental LCA. These methods are based on social effects and use cause-effect chains to estimate the impacts. The widely applied methods are further introduced in Section 7.4.

This chapter will explain the procedures of implementing a product social life cycle assessment, review recent social life cycle assessment works, and demonstrate the social life cycle assessment with a case study of lighting products.

7.2. Fundamentals

According to the Guidelines mentioned above, there are four fundamental terminologies in relation to the social life cycle assessment, including stakeholder, impact category, subcategory and indicator which are defined as follows (Benoît *et al.*, 2009):

Stakeholder A stakeholder category is a cluster of stakeholders who are expected to have shared interests in the investigated product systems. They can be categorized into: Worker, Local Community, Society, Consumer and Value chain actor.

The intention of establishing stakeholder categories is to provide a comprehensive basis for the articulation of the subcategories. The proposed stakeholder categories are deemed to be the main group categories potentially impacted by the life cycle of a product.

Impact Category Impact Categories used in S-LCA correspond to the goal and scope of the study and represent social issues of interest that will be expressed regarding the stakeholders affected and may cover health and safety, human rights, working conditions, socio-economic repercussions, cultural heritage and governance.

Subcategory The subcategories are socially significant themes or attributes. Subcategories are classified according to stakeholder and impact categories and are assessed by the use of inventory indicators, and measured by unit of measurement (or variable).

Indicator The indicators of the social life cycle assessment act as the bridge that links the data with subcategories and impact categories, guiding the data collection process. They can be categorized into additive indicators and descriptive indicators. Descriptive indicators can be further divided into General indicators, which describe broad societal values, international standards top-down approach, and living wage; and Specific indicators, which focus on relevant impacts in a specific process or product (Benoît *et al.*, 2009).

7.3. Steps for Implementing S-LCA

S-LCA complies the ISO 14040 standards, and therefore the four phases for environmental life cycle assessment also are applied for S-LCA, including Goal, Scope, System Boundaries and Functional Unit (Benoît *et al.*, 2009), which are explained in the following sub-sections.

7.3.1 Definition of Goal and Scope, System Boundaries and Functional Unit

The goal of the S-LCA has to be clearly specified to ensure the proper study and implementation of S-LCA. The scope is defined in the first phase of the study that usually encompasses issues of the depth and breadth of the study.

The S-LCA assesses the social impact of the entire life cycle from cradle to grave (Jørgensen *et al.*, 2008). It assesses the social and socio-economic impacts found in the life cycle and provides general data and specific data. The social-economic and social aspects assessed in S-LCA are those that may directly or indirectly affect the positive or negative aspects of the stakeholders in the product life cycle. The functional unit defines the service that needs to be delivered by the product, and ensures that the evaluation target is on an equal basis.

7.3.2 Life Cycle Inventory Analysis

Within the inventory phase of an S-LCA, the data are collected, the systems are modelled, and the life cycle impact results are obtained. The data to be collected are usually for the purposes of

prioritization of actions to be taken in order to reduce the impact based on the S-LCA results, hotspots assessment, site specific evaluation, and impact characterization assessment.

The data collected in the inventory phase enable the assessment of the social impacts of the product's life cycle. Depending on the goal of the study, generic or case-specific data may be used. The Guidelines (Benoît *et al.*, 2009) specify three different types of data that can be used in an S-LCA:

- the activity variables which serve to allocate a socially relevant weight to the different unit processes when dealing with qualitative and semi-quantitative indicators that cannot be referred to the functional unit directly.
- the data related to the social conditions or stressors that will be translated into impacts.
- the data necessary to compare the local situation to an international set of thresholds (the "Performance Reference Points" to be used in the characterization models).

7.3.3 Life Cycle Impact Assessment

The main object of this phase is to categorize the collected data, examine the data quality and use the established method to analysis these data (ISO, 2006). The Guidelines mentioned in Section 1 above define three steps in this phase (Benoît *et al.*, 2009):

- Selection of impact categories, characterization methods and models
- Linkage of inventory data to particular S-LCIA subcategories and impact categories
- Determination and/or calculation of subcategory indicator results

The main S-LCA methods that are widely used by the researchers will be presented in Section 4.

7.3.4 Life Cycle Impact Interpretation

Life Cycle impact interpretation is the process of assessing results in order to draw conclusions. In accordance with the goal and scope of the study, this phase has several objectives: to analyse the results, reach conclusions, explain the limitations of the study, provide recommendations and report adequately.

7.4. Main Assessment Methods for S-LCA

There are several assessment methods developed by researchers for S-LCA. Listed below are the brief introduction of the major methods used in this subject area.

7.4.1 Performance Reference Point Method

This method is to assess the relative position of the state of a unit process impact subcategory (or indicator) in reference to one or more international instruments or best practice (threshold). This type of data and assessment (using performance reference points) is common in the field of corporate social responsibility and is frequently used in S-LCA.

The reference points are usually based on internationally accepted minimum performance levels like the International labour organisation conventions, the ISO 26000 guidelines on social responsibility, and OECD Guidelines for Multinational Enterprises (ISO, 2010; Parent, Cucuzzella and Revéret, 2010). This method typically utilises scoring method for the impact subcategories and scoring aggregations for the final stakeholder category score or impact category score. The scoring methods can be two levels (e.g. yes or no, or 1 or 0) (Aparcana and Salhofer, 2013; Foolmaun and Ramjeeawon, 2013) or multi-level (Dreyer, Hauschild and Schierbeck, 2006; Hutchins and Sutherland, 2008; Citroth and Franze, 2011; Ekener-Petersen and Finnveden, 2013). They use a classification system based on the strength of the effect of social impacts, communicated with colour codes in a green–yellow–red scale.

In the Guidelines, there is a proposal to use performance reference points, these being ‘internationally set thresholds or goals or objectives according to conventions and best practices’ (Benoît et al., 2009). The advantage with this approach is that it represents a clear and intuitive way of communicating the results to interested stakeholders. Additionally, this method helps understand the magnitude and the significance of the data collected in the inventory phase.

7.4.2 Impact Pathway Method

Impact pathway method assesses the social impacts of products or services by utilising impact pathways as characterisation models that consists of midpoint and endpoint indicators like environmental LCA (Parent, Cucuzzella and Revéret, 2010). This method is based upon the causal relationship between processes. For example, requiring excessive working time may cause workers to experience higher stress levels; high stress levels may cause depression (a midpoint); depression will result in a loss of psychological wellbeing (endpoints).

There are two typical characterisation frameworks for the impact pathway method: single impact pathway that measures a single social issue, and multiple impact pathways. Some case studies with single impact pathway focused on AoP (area of protection) of human (Norris, 2006; Hutchins and Sutherland, 2008; Feschet *et al.*, 2013). They established the causal relationships between national health improvement (e.g. life expectancy or infant mortality) and economic growth (e.g. GDP). Except the fields of public health and epidemiology, there are limited studies in the search for social impact pathways case studies.

Petti, Ugaya and Di Cesare (2014) reviewed 35 publications related to S-LCA case studies. Among those publications, 68% carried out the case study by using the reference point method, while 6 % implemented the impact pathway method. This does not mean that the reference point method is better, but rather the impact pathway method is difficult to classify the impact pathways and collect relevant and specific data of a product or service. It was concluded that the reference point method measures the overall social performance which relates to the relative importance of each context unit over the entire product system (Parent, Cucuzzella and Revéret, 2010). Whereas the impact pathway method measures the social impacts of specific products which relates to the functional unit stated in assessment.

7.4.3 Checklist Method

The checklist-based impact assessment method uses the tick (✓) sign against the presence of an impact. This method can only conclude the evaluated impact exist or not. Ciroti and Franze (2011) compared the social life cycle impacts for rose flowers from the Ecuador and Netherland, with focus on production and packaging stages. The rationale for evaluating the impact performance can be described as follows:

- If the subcategory affects impact categories, then the impact categories are marked with ‘✓’.
- If the subcategory doesn’t affect impact categories, then the impact categories are marked with ‘-’.
- If there is no effect between the subcategory and impact category, or there is no evidence support the evaluation, then the impact category is left with blank
- The assessment column is marked with five level colours. The impact category row with the most ‘✓’ will be marked with the darkest colour in the row assessment box. The impact

category row with the least 'v' will be marked with the lightest colour in the row assessment box.

Through comparison between the assessment forms, it can be found that the social impacts for rose flowers produced in the Ecuador are worse than the rose flowers products in the Netherland.

7.4.4 Scoring Method

The scoring method uses scores to assess an impact. A variety of scoring methods and standards have been developed to apply in the implementation of product S-LCA. Foolmaun and Ramjeeawon (2013) investigated the social impacts of four solutions for recycled PET bottles in Mauritius. Questionnaire was used to collect the evidences according to the established subcategories and indicators, and the collected data and information are then converted into quantitative figures by applying the established scoring standards. For example, the number of workers answering 'yes' to the question on wage satisfaction in the survey, which would represent the fraction of the sampled population of workers satisfied with their wages. Then mark the percentages of each subcategory based on the established scoring standards and calculate the total scores of each subcategory for the disposal procedures. Scoring for each solution based on the percentages of each disposal procedures to determine which solution is the appropriate one, the analysis shows 75 % flake production and 25 % landfilling is the best solution for this case.

Another scoring method was used by Ciroth and Franze (2011) where negative and positive impacts are rated by assigning values from 1 to 6 (1 for positive and 6 for very negative impacts). However, there are arguable elements such as assessing the lack of forced labour as a positive aspect, whilst this merely put it back to neutral impacts at the best.

7.4.5 Database Method

According to the literature search, the Social Hotspot Database (Norris, Aulisio and Norris, 2012) and PSILCA (Ciroth and Eisfeldt, 2017) are the two major databases applicable in S-LCA practices. Both database comply with the categories and indicators framework that are defined by the Guidelines (Benoît *et al.*, 2009) and 'The Methodological Sheets' (UNEP-SETAC, 2013). Global government and organizational statistics reports are the main data sources for the two databases that cover hundreds of nations and regions, and sectors. Using the database to model the product system for S-LCA and conduct the evaluation is time-efficient for the data collection phase.

Ekener-Petersen, Höglund and Finnveden (2014) implemented screening level S-LCA for fossil fuels and biofuels for vehicles by using SHDB data and concluded that it is clearly shown that there are risks of substantial negative social impacts from fossil fuels, at the same levels as for biofuels. Ekener *et al.* (2018) also integrated the different sustainability perspectives into one holistic outcome for sustainability by considering different stakeholder profiles and negative as well as positive social impacts, which is also validated in the case of biomass based and fossil transportation fuels. The analysis results show that it is important to include positive social impact categories for the future S-LCA practices (Ekener, Hansson and Gustavsson, 2018) as the existing S-LCA studies has limited considerations for the positive impacts.

The database PSILCA v2.1 (Ciroth and Eisfeldt, 2017) was used to establish the background system's inventory of small-scale apparel product chains in Peru, in order to increase consumer transparency and social awareness (Villegas *et al.*, 2018). The PSILCA database also provided background information for the stakeholder of rural cassava starch factories in Cauca-Colombia, and the greatest impacts occur in the cassava producers among all the stakeholders. The analysis results show that positive impacts can be generated regarding job creation, food security/ sovereignty, gender equality, gender wage gaps, food security and sovereignty, and others (Güereca, 2018).

Werker, Wulf and Zapp (2018) used PSILCA to implement S-LCA for industrial hydrogen production by alkaline water electrolysis that is produced in Switzerland and operating in Germany. PSILCA provides sector level data for a risk level of 19.5 medium risk hours for hydrogen production in Germany).

Eynard et al. (2018) used PSILCA to perform a macro-scale assessment of social performance of the mining and quarrying sector in six extra-EU countries, compared to the EU-28 average. This analysis results show that in the case of the EU mining and quarrying sector, the three top locations contributing to the social indicator for the impact category “fair salary” are India, China and UK.

Note that the S-LCA databases covers many different aspects related to social sustainability. However, in some cases the existing databases, such as PSILCA and SHDB, have limitations in representing specifically how an economic sector affects social conditions. Indeed, many indicators refer to the situation of the country rather than reflecting sectors performance (Mancini and Sala, 2018).

7.4.6 Empirical Method

The empirical method involves the use of empirical formulas or rules in order to assess social impacts. Weidema (2006) proposed QALYs (Quality Adjusted Life Years) as the functional unit for the Human Being), which is similar to the functional unit DALYs (Disability Adjusted Life Years) in the practices of environmental life cycle assessment. Labuschagne and Brent (2006) developed a quantitative based formula to evaluate social life cycle impacts based on the South Africa Resource Impact Indicator approach. Feschet et al.(2013) used Preston Pathway (curve) to evaluate the health, education, employment impacts that related to the banana industry in the Cameroon.

7.4.7 Environmental Life Cycle Inventory Database Method

In environmental LCI database method, the environmental LCI database is used for estimating social impacts. This approach is similar to environmental life cycle impact assessment, therefore, the functional unit, system boundary of the social life cycle is required to keep consistent with the settings for the environmental life cycle. Additionally, this method can only evaluate the impact performance related to the health and employment aspects instead of the all range impact categories that are defined by the Guidelines (Benoît *et al.*, 2009).

7.5. Case Study

This section is to demonstrate the S-LCA for a lighting product manufacturing company. Due to a confidentiality reason, the company’s name cannot be mentioned. In this case study, the S-LCA is focused on the company’s aspects related to the manufacture phase of the lighting products. This assessment is conducted using the checklist method, scoring method and reference points method.

7.5.1 The schematic and rating scale

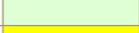
The stakeholder category and subcategory selection following the Guidelines (Benoît *et al.*, 2009) and the indicator selection are confirmed first in the S-LCA process, which are presented in Table 7.2.

Within the S-LCA, not only the impacts but also the performance of the company have to be assessed. The performance is assessed by comparison to the Performance Reference Points (see Appendix 1), with assessment results shown in the third column of Table 7.3. The impact is assessed against the impact categories, which include Working conditions, Health and safety, Human rights, socio-economic repercussions, Indigenous rights, and Governance, as shown in Table 7.3 where each fields of impact categories are signed √ or (√) for the one with high or low influence on the society aspects, and (-) for not relevant or data not available.

The data collection is indispensable to the inventory analysis process. The indicator performance is illustrated by the data presented in the last column (Status) of Table 7.2. The data were collected from relevant sources such as the company's annual reports and Website. Both the social performance and the social impact are assessed based on data shown in the Status column of Table 7.2.

Each subcategory is assessed twice, one for the performance assessment and the other for the impact assessment, with a colour system ranging from very good performance to very poor performance, and positive effects to negative effects, by following the grades presented in Table 7.1.

Table 7.1. The rating scale (Ciroth and Franze, 2011)

Performance assessment	Impact assessment	Colour	Factor
Very good performance	Positive effect		1
Good performance	Lightly positive effect		2
Satisfactory performance	Indifferent effect		3
Inadequate performance	Lightly negative effect		4
Poor performance	Negative effect		5
Very poor performance	Very negative effect		6

As indicated in Table 1, the factor values are arranged from 1 to 6, of which a lower value is better, while a higher value is worse. In this case study, as shown in Table 7.3, the sub-score of subcategories for a stakeholder category is the average value of the factors assigned to the subcategories of the corresponding stakeholder group, and the final aggregate score is the average value of the sub-scores. Please note that this is a simplified method for an indication purpose only. For a more accurate calculation method, please see (Ciroth and Franze, 2011).

Table 7.2 S-LCA table of the company

Stakeholder	Subcategory	Indicator	Status
Workers	discrimination	presence of formal policies of equal opportunities	Realizing a culture of performance was grounded in proper human resource management practices, high quality feedback, transparency and acting on performance and talent outcomes. The company paid attention to individual staff member's career development, and support the employees to gain skills and updating knowledge with relevant technologies such as automation and artificial Intelligence
		gender discrimination	In 2017, the rate of female and male in staff is 42/58 professional 31/69, management, 23/77, executives, 18/82, in total, 35/65. However, this situation slightly improved from that of 2015-2016.
		percentage of woman in labour force in country/sector/organization	no data
	health and safety	accident rate of the country/sector/organization	In the company, Health and Safety performance has continued to improve. A number of sites showed outstanding safety performance, for example, the Healthcare Pune site in India reached a significant milestone by achieving over 3 million man-hours without a Lost Workday Injury Case (LWIC) by the end of 2015 (over 3 years without an accident). Consumer Lifestyle implemented a Lean Behaviour Based Safety program resulting in significant improvement in both incident statistics and overall safe behaviour for the entire site. It is viewed as an internal best practice program with plans to be deployed globally at all manufacturing units within the company beginning in 2016, the rate of Lost Workday Injury Case (LWIC) 2011-2015 ranking from 0.67-0.34.
		description of protection measures	The company considered that job is a part of life, therefore they provided welfare and health insurance to protect their staff mentally and physically healthy.
		description of reported violations	At present, there is no data reported about violations of the company.
	child labour	percentage of child labour in country/sector/organization	The company published an official document of child labour policy, they defined the child labour as those under 15 years old and cited the ILO standards to reduced hiring child labour in the company's policy documents to stop hiring the underage child.

		kind of child labour in the company	The company presented that child labour problems cannot be avoided, and they endeavour to protect the child in case of injury (Koninklijke Philips N.V., 2015)(Koninklijke Philips N.V., 2015)(Koninklijke Philips N.V., 2015)(Koninklijke Philips N.V., 2015). No data were found about the child labour rates.
	working hours	hours of work per employee and month in average	The working time of workday is 9:00 am - 6:00 pm, therefore the average working time per month is roughly 200 hours.
		working over time	Some former employees of the company complained that the company had wrong human resource arrangement and overtime work, which was the reason why they quitted their job.
	labour force	frequency of forced labour in country/sector/enterprise	no data
		description of kind of forced labour in the company	no data
Consumer	health and safety	presence of consumer complaints	With the results of analysing the views of the company's lighting product shown in e-commerce platform Tianmao, there were positive remarks of the products produced by the company..
		risks of the product regarding consumers health and safety	no data
	consumer privacy	related publications to protect consumer privacy	The company has a longstanding commitment to respect the privacy of their consumers, customers and other individuals. As the company transform into a digital company, complying with the company privacy standards is increasingly important to achieve that commitment.
	transparency	presence of certifications or labels for the products/sites	To create a global approach on the protection of privacy and to allow internal data transfers between the companies worldwide, the company has adopted a set of Binding Corporate Rules.
		percentage of organizations within the sector which published a sustainability report	The company publish a wide range reports explaining the company's efforts in the improvement of sustainability performance.

	end of life responsibility	the rate of recycle in the products	The company places greater emphasis on circular economic, they continue to make positive progress towards a circular economy by recycling 69% of industrial wastes. At the end of 2017, 3 out of 5 Connected Care & Health Informatics businesses' manufacturing sites reported zero waste to land. Based on detailed action plans the company works closely with the remaining sites to achieve zero waste to land status by the end of 2020.
		attention to management of end-of-life issues	Evidences were shown in the company's annual report 2017.
Society	contribution to economic development	contribution of the product /company to economic development	The quota of the company selling in total from 53 million in 2015 to 55 million in 2016.
	technology development	sector efforts in technology development regarding eco-friendliness	no data
		presence of partnership regarding research and development	The company endeavour to use advanced technology to protect people health and safety. with the partner shared the same commitments
	corruption	risk corruption in country/sector	Some former employees complained that that the company had a serious corruption problem, which lead to wrong human arrangement and overtime work.
		presence of anti-corruption program in the company	no data

Table 7.3 The S-LCA assessment results

Stakeholder Group	Subcategory	Performance Assessment	Impact categories						Impact Assessment
			Working Conditions	Health and Safety	Human Rights	socio-economic repercussions	Indigenous Rights	Governance	
Worker	Discrimination	4	(√)	(√)	√	√	√	√	5
	Health and Safety	1	√	√	√	√	√	√	1
	Child Labour	3	√	√	√	√	(√)	√	4

	Working Hours	5	(√)	√	√	√	(√)	√	3
	Force Labour	-	-	-	-	-	-	-	-
	Sub-score	3.25							3.25
Consumer	Health and Safety	2	√	√	√	√	√	√	2
	Feedback Mechanism	-	-	-	-	-	-	-	-
	Consumer Privacy	2	(√)	√	√	(√)	(√)	√	1
	Transparency	2	√	√	√	√	√	√	1
	End of Life Responsibility	2	√	√	√	√	√	√	1
	Sub-score	2							1.25
Society	Contribution to Economic	1	√	√	(√)	√	√	√	1
	Technology Development	1	√	√	√	√	√	√	1
	Corruption	4	√	(√)	√	√	(√)	√	5
	Sub-score	2							2.33
	Final aggregate score	2.41							2.27

7.5.2 Life Cycle Inventory Analysis

As shown in Tables 2 and 3, in this case study, four stakeholders are selected: workers, consumer, local community, and society. The numbers of subcategories and indicators for each stakeholder category are as follows:

- 5 subcategories and 12 indicators are defined for the Worker stakeholder category
- 5 subcategories and 7 indicators are defined for the Consumer stakeholder category
- 3 subcategories and 3 indicators are defined for the Local Community stakeholder category
- 3 subcategories and 5 indicators are defined for the Society stakeholder category

These factors are defined based on the identified data and information that are presented in Table 7.3.

7.5.2.1 Workers

(1) Assessment of the Discrimination subcategory

Two indicators are considered for this subcategory: 'presence of formal policies of equal opportunities', and 'gender discrimination', while the third indicator 'percentage of woman in labour force in country/sector/organization' is not considered because there is no data available. Based on the data collected, which are shown the last 'Status' column in Table 7.2, the performance and impact of this subcategory against the two indicators are assessed as follows.

For the indicator 'presence of formal policies of equal opportunities', the status data indicate that the company implemented the policies of equal opportunities by realizing a culture of performance with human resource management practices, high quality feedback, transparency and acting on performance and talent outcomes. Therefore, the company had positive facts regarding this indicator.

For the indicator 'gender discrimination', the company's annual report shows that the overall gender ratio of female to male was 35/65 in 2017, i.e., the member of male staff was almost two times of female staff members. This is a negative fact. However, the recent data shows that the overall ratio smoothly grows, which means that the company's gender situation is improving. With the above analysis and reference to the Performance Reference Points regarding Discrimination: 'no occurred of discrimination further, companies should employ minorities and the employment ratio men and women should be balanced' (See Appendix 1), it can be concluded that discrimination exists in the company in term of the second indicator, but there also have some positive aspects regarding the first indicator. Therefore, the performance score for this subcategory is 4 points. Although the influences in the impact category working conditions and health and safety are relatively small, and the rest impact categories are much bigger, therefore, the impact assessment are scored as 5 points.

(2) Health and Safety

The company's annual report (Phili) shows that company's health and safety performance has continued to improve and has an excellent performance in the area. The Lost Workday Injury Case (LWIC) use a datum to assess the enterprise performance in the health and safety, and it reported that the injury rate keeps falling from 2011 to 2015, ranking in 0.67 to 0.34 in the lighting industry. The company has taken various measures to protection their labour, they considered that job is a part of life, and they provided welfare and health insurance to protect their staff mentally and physically healthy. At present, there is no violation incidents reported. Compared to the regulation in the performance reference points, 'adequate management of health and safety, so that the risk of workers is low', the score of performance assessment is 1 point because the three indicators show positive effects. The impact assessment is scored and remained as 1, because the impact category shows a bigger influence in all areas.

(3) Child Labour

The performance of Child Labour is represented by two indicators: the percentage of child labour, and kind of child labour in the company. The company published an official company child labour policy to define that the child labour as children who under 15 years and is assigned different working intensity and working hours to children of different ages. At present the company doesn't declare the number of child labours employed in the company, but the company admits that child hiring labour is an inevitable matter. Therefore, the policies are established to protect the benefits of their child labour. On the other hand, the company does not specify which type of child labour the company uses, according to the ratio of child labour in different countries, it could be concluded that the type of force is labour-intensive job and in developing countries. These findings show that the company is incompatible to the performance reference points 'no occurrence of child labour'. No matter what the performance they have, they show a positive attitude to the child labour and use clear policies to protect their benefits. Thus, the performance of child labour is defined as 3 in the assessment, the impact assessment is scored in 4 because the impact category cause bigger influence indigenous rights.

(4) Working Hours

There are two indicators: 'hours of work per employee and month in average' and 'over time'. The working time of workday is 9:00-6:00, therefore the average working time per month is approximately 200 hours. The performance reference point regulated that 'the length of the working hours far exceeds the working time should not exceed 8 hours per day and 48 hours per week'. Therefore, the company has shown unsatisfied performance in this perspective, so the score is defined as 5 points. In the performance of the impact category, there is a smaller impact on the working condition and the indigenous rights, so the score on the impact assessment is 3 points.

(5) Forced Labour

There is no data and information available to support the assessment.

7.5.2.2 Consumer

(1) Health and Safety

There are two indicators for the health and safety subcategory: presence of consumer complaints, and risk of product regarding consumer health and safety. Based on the information obtained from e-commerce Websites, the findings show that majority of the consumers highly praise the the company's products, and the few complaints are caused by the delivery services that are provided by the third professional logistical company. Furthermore, the online consumer review shows that the best-selling lamp products of the company are commented with very high rate. Performance reference point regulated that 'the company should minimize health and safety risks of products', and the company's performance in this perspective is also positive. Therefore, the performance score is 2 points, and all the impact categories have high impact, so the impact assessment is scored with 1 point.

(2) Consumer Privacy

In the respect of consumer privacy, two indicators are involved: related publications and protect consumer privacy, the company has a longstanding commitment to respect the privacy of consumers, and has established the privacy rules specifying reasons for customer data, and strict confidentiality protocol. From the performance reference points stipulated by 'companies should conduct regarding their product and social responsibility in a transparency way, the communication should enable an informed consumer choice', the company shows good performance in this respect,

but the risk of leaking data stills exists, therefore, the performance assessment is set as 2 points. In terms of impact subcategories, there is a smaller impact on working conditions, socio-repercussions, and indigenous, so the performance on impact assessment keeps consistent, and the score is still 2 points.

(3) Transparency

There are two indicators in the aspect of transparency subcategory: presence of certification or labels for the products/sites, and the percentage of organizations within the sector which publishes the sustainability reports. The company created a global approach on the protection of privacy and allows internal data transfer between its companies worldwide; additionally, the company has adopted a set of Binding Corporate Rules regarding Privacy Rules. In the performance reference points, it is stated that 'company should communicate regarding their product and social responsibility in a transparent way the communication should enable an informed consumer choice'; therefore, the performance assessment is set at 2 points. In terms of impact subcategories, there is a bigger impact on all aspects, so the score is defined as 2 points.

(4) End of Life Responsibility

There are two indicators in the end of life responsibilities: the recycle rates of the products, and attention to management of end-of-life issues. The company's 2017 annual report indicates that the company made great efforts to the circular economy and the recycling rate of industrial waste reached 69%, but there is still a part of non-recyclable industrial waste that needs to be landfilled. In 2012, they achieved zero waste development goals. In the performance reference points, companies should provide information to consumers regarding appropriate end-of-life options, if relevant manufactures of electronic products should establish product take back systems and should secure appropriate product disposal'. Philips performs well in this perspective, so the score is 2 points, furthermore, it has a large impact on impact subcategories, and the score for impact assessment is 1 point.

7.5.2.3 Society

(1) Contribution to Economic

The indicator of contribution to economic is the contribution of the product /company to economic development. The company's total sale quota increase from 53 million in 2015 to 55 million in 2016, and the sales of lamps manufactured by the company reached 5.5 billion in 2016. The performance reference points 'The company should contribute the local economic development through different aspects as payment of wages purchase of raw materials and supplies investments etc'. Because the company has a positive impact on the economy, resulting in good results in the performance assessment, then it is scored as 1 points, and the impact category is also obtained 1 point.

(2) Technology Development

There are two indicators for the technology development: sector efforts in technology development regarding eco-friendliness, and presence of partnership regarding research and development. The company endeavours to use advanced technology to protect people's health and safety. In the performance reference points, it is stated that 'companies acting in technology relevant areas should engage in the development of efficient and environmental sound technologies'. Thus, it can conclude that the company has good performance, so the score is 1 point, and the impact category is also obtained 1 point.

(3) Corruption

The staff members of the company complained that the company serves a serious corruption problem, which resulted in wrong human arrangement and overtime work. The Performance reference points indicate that 'companies should not be involved into cases of corruption and should implement appropriate measures to prevent corruption'. The company should endeavour to cope with these issues for a better performance, and hence resulted in 4 points for this category. Through the evaluation of the impact categories, there are two smaller influences and 4 bigger influences leading to a score of 5 points to the resulting impact assessment.

7.5.3 Comments on the Assessment Results

The results reveal the following positive aspects of the S-LCA for the company in relation to the production of their lighting products:

- The overall social performance assessments (PA) and impact assessments (IA) of the company are resulted with aggregate scores 2.41 and 2.27 respectively. Considering the range of the score is 1.00 – 6.00, the results are reasonably good.
- It is particularly good for the subcategories of health and safety, Contribution to economic, and Technology development, with score 1 of both PA and IA for all the three subcategories.

However, considerable attention must be given to improve to the following subcategories

- Discrimination with assessment scores PA = 4 and IA = 5,
- Child labour with scores of PA = 3 and IA = 4

It has to point out that this case study is for illustration purpose only in order for the reader to understand the assessment procedure and application of relevant assessment methods, but the data collected are not sufficient enough to give more accurate assessment results.

7.6. Concluding Remarks

This chapter is an introductory of the S-LCA, including the fundamental terminologies, S-LCA procedure, assessment methods, and a case study to illustrate the application of the assessment methods to the S-LCA of a lighting company.

The information presented in this chapter is valuable for the reader to understand the S-LCA technology. The review of S-LCA methods and the case study are particularly helpful to understand the assessment procedure and application of relevant assessment methods.

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Appendix 7.1 List of Performance Reference Points (Ciroth and Franze, 2011)

Subcategory	Performance Reference Points	Basis
	time and do not withhold shares of the salary.	<ul style="list-style-type: none"> ■ UNEP/SETAC method sheets
Working time	The working time should not exceed 8 hours per day and 48 hours per week.	<ul style="list-style-type: none"> ■ ILO labour standards ■ UNEP/SETAC method sheets
Discrimination	No occurrence of discrimination. Further, companies should employ minorities and the employment ratio men to women should be balanced.	<ul style="list-style-type: none"> ■ ILO labour standards ■ UN Declaration on Human Rights ■ OECD Guidelines for Multinational Enterprises ■ UN Global Compact ■ IFC Performance Standards on Social and Environmental Sustainability ■ The Global Sullivan Principles ■ UNEP/SETAC method sheets
Health and safety	Adequate management of health and safety, so that the risk of workers is low.	<ul style="list-style-type: none"> ■ ILO labour standards ■ ISO 26000 ■ IFC Performance Standards on Social and Environmental Sustainability ■ The Global Sullivan Principles ■ UNEP/SETAC method sheets
Social benefits/ social security	Companies should provide social benefits as for instance medical insurance or pension insurance, which ensure a decent standard of living. Other social benefits as swimming pools, staff cars, or the like are classified as rather unimportant.	<ul style="list-style-type: none"> ■ ILO labour standards ■ UNEP/SETAC method sheets
Access to material resources	Companies should not overexploit material resources and should implement certified environmental management systems to minimise resource consumption. In addition, companies should improve community infrastructure, if the infrastructure is underdeveloped or not sufficient for a decent standard of living.	<ul style="list-style-type: none"> ■ UN Declaration on Human Rights ■ ISO 26000 ■ ISO 14000 ■ OECD Guidelines for Multinational Enterprises ■ UN Global Compact ■ IFC Performance Standards on Social and Environmental Sustainability ■ The Global Sullivan Principles ■ UNEP/SETAC method sheets
Access to immate-	Companies should provide for one	<ul style="list-style-type: none"> ■ UN Declaration on Human

Subcategory	Performance Reference Points	Basis
Local employment	Companies should contribute directly or indirectly through local suppliers to the reduction of local unemployment.	<ul style="list-style-type: none"> ■ ISO 26000 ■ OECD Guidelines for Multinational Enterprises ■ ILO conventions ■ UNEP/SETAC method sheets
Community engagement	Companies should engage in their communities in different areas. In addition, companies should include community stakeholders in relevant decision-making processes.	<ul style="list-style-type: none"> ■ ISO 26000 ■ OECD Guidelines for Multinational Enterprises ■ IFC Performance Standards on Social and Environmental Sustainability ■ The Global Sullivan Principles ■ UNEP/SETAC method sheets
Public commitments to sustainable issues	Companies should contribute to the sustainable development of the society with regard to the impacts from their activities.	<ul style="list-style-type: none"> ■ OECD Guidelines for Multinational Enterprises ■ UNEP/SETAC method sheets
Contribution to economic development	Companies should contribute the local economic development through different aspects as payment of wages, purchase of raw materials and supplies, investments etc.	<ul style="list-style-type: none"> ■ ISO 26000 ■ OECD Guidelines for Multinational Enterprises ■ UNEP/SETAC method sheets
Prevention and mitigation of conflicts	Companies located in regions with a high risk of conflicts due to resource depletion, massive pollution or poor working standards should try to reduce the risk by dint of appropriate measures	<ul style="list-style-type: none"> ■ UNEP/SETAC method sheets
Technology development	Companies acting in technology relevant areas should engage in the development of efficient and environmental sound technologies.	<ul style="list-style-type: none"> ■ ISO 26000 ■ OECD Guidelines for Multinational Enterprises ■ UN Global Compact ■ UNEP/SETAC method sheets
Corruption	Companies should not be involved into cases of corruption and should implement appropriate measures to prevent corruption.	<ul style="list-style-type: none"> ■ ISO 26000 ■ OECD Guidelines for Multinational Enterprises ■ UN Global Compact ■ The Global Sullivan Principles ■ UNEP/SETAC method sheets
Fair competition	Companies should act fair, i.e. not anti-competitive.	<ul style="list-style-type: none"> ■ ISO 26000 ■ OECD Guidelines for Multinational Enterprises

Subcategory	Performance Reference Points	Basis
		<ul style="list-style-type: none"> ■ United Nations Set of principles and rules on competition ■ The Global Sullivan Principles ■ UNEP/SETAC method sheets
Promoting social responsibility	Companies should promote social responsibility among suppliers, including monitoring, audits, and training with regard to social responsible behaviour.	<ul style="list-style-type: none"> ■ ISO 26000 ■ OECD Guidelines for Multinational Enterprises ■ IFC Performance Standards on Social and Environmental Sustainability ■ The Global Sullivan Principles ■ UNEP/SETAC method sheets
Supplier relationships	Companies should develop supplier relationships, which base on mutual co-operation. Companies should act fair regarding their suppliers and should support them, if necessary.	<ul style="list-style-type: none"> ■ UNEP/SETAC method sheets
Respect of intellectual property rights	Companies should respect intellectual property rights and should not infringe patent rights.	<ul style="list-style-type: none"> ■ ISO 26000 ■ The Global Sullivan Principles ■ UNEP/SETAC method sheets
Health and safety	Companies should minimise health and safety risks of products.	<ul style="list-style-type: none"> ■ ISO 26000 ■ OECD Guidelines for Multinational Enterprises ■ UNEP/SETAC method sheets
Feedback mechanism	Companies should implement feedback mechanisms to come in contact with consumers in an uncomplicated way.	<ul style="list-style-type: none"> ■ ISO 26000 ■ OECD Guidelines for Multinational Enterprises ■ UNEP/SETAC method sheets
Transparency	Companies should communicate regarding their product and social responsibility in a transparent way. The communication should enable an informed consumer choice.	<ul style="list-style-type: none"> ■ ISO 26000 ■ OECD Guidelines for Multinational Enterprises ■ UNEP/SETAC method sheets
End of life responsibility	Companies should provide information to consumers regarding appropriate end-of-life options, if relevant. Manufactures of electronic products should establish product take back systems and should ensure appropriate product disposal.	<ul style="list-style-type: none"> ■ WEEE directive ■ UNEP/SETAC method sheets

Subcategory	Performance Reference Points	Basis
rial resources	thing freedom of expression; for another thing they should support communities in education or other community services, if necessary.	Rights <ul style="list-style-type: none"> ■ The Global Sullivan Principles ■ UNEP/SETAC method sheets
Delocalisation and migration	Companies should not cause resettlements or migration movements on a large scale. If resettlements are necessary companies should provide appropriate compensations.	<ul style="list-style-type: none"> ■ UN Declaration on Human Rights ■ IFC Performance Standards on Social and Environmental Sustainability ■ UNEP/SETAC method sheets
Cultural heritage	Companies should respect cultural heritage and do not infringe cultural customs and traditions in any way.	<ul style="list-style-type: none"> ■ UN Declaration on Human Rights ■ ILO conventions ■ Universal Declaration on Cultural Diversity ■ IFC Performance Standards on Social and Environmental Sustainability ■ UNEP/SETAC method sheets
Respect of indigenous rights	Companies should respect indigenous rights, including the rights to lands, resources, cultural integrity, self-determination, and self-government.	<ul style="list-style-type: none"> ■ UN Declaration on Human Rights ■ Indigenous rights ■ ILO conventions ■ UN Declaration on the Rights of Indigenous Peoples ■ IFC Performance Standards on Social and Environmental Sustainability ■ UNEP/SETAC method sheets
Safe and healthy living conditions	Companies should minimise their environmental pollution in order not to jeopardise the health of community members.	<ul style="list-style-type: none"> ■ UN Declaration on Human Rights ■ ISO 26000 ■ IFC Performance Standards on Social and Environmental Sustainability ■ The Global Sullivan Principles ■ UNEP/SETAC method sheets
Secure living conditions	In countries with high crime rates companies should contribute to secure living conditions through private security personnel.	<ul style="list-style-type: none"> ■ UN Declaration on Human Rights ■ IFC Performance Standards on Social and Environmental Sustainability ■ UNEP/SETAC method sheets

Subcategory	Performance Reference Points	Basis
Freedom of association and collective bargaining	Freedom of association and collective bargaining should be ensured. The forming and joining of independent trade unions should be possible.	<ul style="list-style-type: none"> ■ ILO labour standards ■ UN Declaration on Human Rights ■ OECD Guidelines for Multinational Enterprises ■ UN Global Compact ■ IFC Performance Standards on Social and Environmental Sustainability ■ The Global Sullivan Principles ■ UNEP/SETAC method sheets
Child labour	No occurrence of child labour.	<ul style="list-style-type: none"> ■ ILO labour standards ■ OECD Guidelines for Multinational Enterprises ■ UN Global Compact ■ IFC Performance Standards on Social and Environmental Sustainability ■ The Global Sullivan Principles ■ UNEP/SETAC method sheets
Forced labour	No occurrence of forced labour.	<ul style="list-style-type: none"> ■ ILO labour standards ■ OECD Guidelines for Multinational Enterprises ■ UN Global Compact ■ IFC Performance Standards on Social and Environmental Sustainability ■ The Global Sullivan Principles ■ UNEP/SETAC method sheets
Fair salary	The wage level should ensure a decent standard of living. The payment of the minimum wage is often not sufficient. Further, companies should pay in	<ul style="list-style-type: none"> ■ ILO labour standards ■ UN Declaration on Human Rights ■ The Global Sullivan Principles