FRIM
TIMBER TECHNOLOGY BULLETIN
NO. 105, 2020
ISSN: 139-258

CONCEPT OF LIFE CYCLE ASSESSMENT (LCA) IN TIMBER INDUSTRY

Geetha R, Gan KS & Zairul AR

INTRODUCTION

Wood is well known as a renewable material. It continues to store carbon during its service life, hence has the potential to mitigate climate change. The process is demonstrated from the uptake and storage of carbon by tree in the forest in Figure 1.

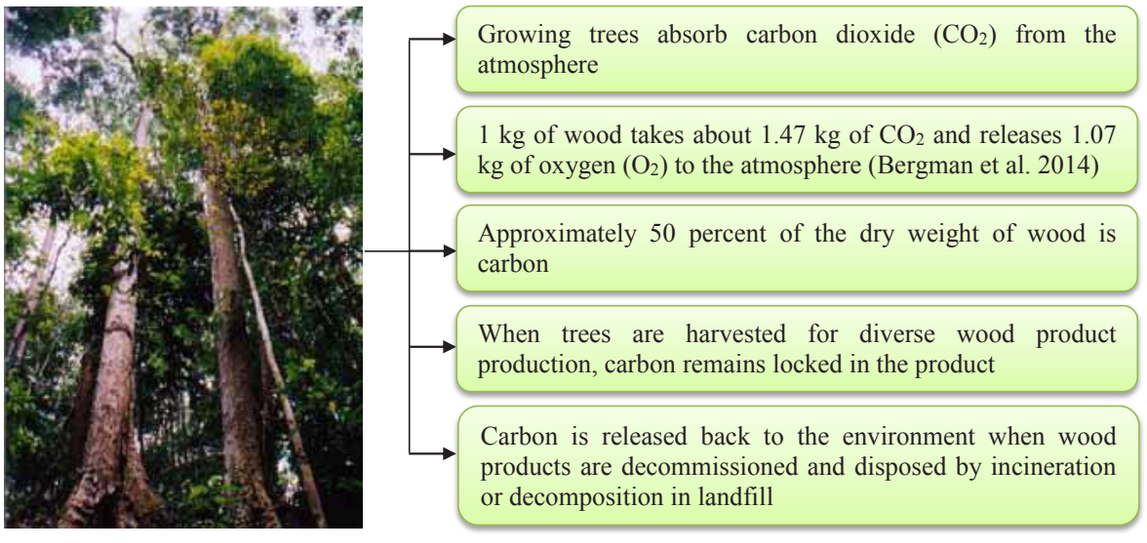

Figure 1 Carbon cycle of wood products

The embodied energy of wood is lower than any other building materials like steel, aluminium, plastic or concrete. Table 1 shows the embodied energy for the common building materials. Embodied energy is defined as the quantity of energy consumed during the production activity. Consequently, wood has a lower overall impact on the environment than its counterparts.

Table 1 Embodied energy for common building materials

Material	Embodied energy (MJ/kg)
Timber	7.11
Particleboard	12.25
Plywood	13.58
Glue laminated timber	12.06
Medium density fibreboard	11.02
Steel	29.36
Aluminium	157.10

Source: MTC 2017

As a material, wood is highly versatile, and it is being used for various purposes. It is harvested and manufactured in large scale for building materials and various wooden products. Wood residues may be manufactured into fibre products or use as biomass energy. Discarded wood can be reused or recycled into new products, thus prolonging the service life of wood. Along with the growing importance of wood is the concern with global environmental issues. The issues are not with the products, but with the products' life cycle (Guinée et al. 2011). Such issues drive the governments and stakeholders to incorporate the assessment of potential environmental impacts in policy decisions.

LIFE CYCLE ASSESSMENT (LCA)

The timber industry is very much depending on natural resources, namely wood, energy and water to carry out its activities. As a result, environmental emissions to the air, land and water is triggered in different types and quantities which consequently impacts the environment (Meil et al. 2007; Eshun et al. 2010; Bergman & Bowe 2012). The concerns among the global societies are increasing with the alarming environmental issues, particularly global warming. Therefore, it is crucial to develop 'greener products' or 'greener processes'. An integrated approach of life cycle assessment (LCA) emerges to be broadly applied by governments and stakeholders to assess the environmental performances of products or services.

> Life cycle assessment (LCA) is a methodological framework to assess the environmental aspects and potential environmental impacts of product (goods and services) throughout its life cycle

Life cycle of timber industry

The life cycle associated with timber industry begins with resources extraction, followed by production activities, use of product and end with disposal which is known as cradle-to-grave. Transportation activities develop a physical link when needed. The activities in every life cycle stage are interdependent, such that the output from one of the stage will be the input for the next life cycle stage. The life cycle associated with timber industry is illustrated in Figure 2.

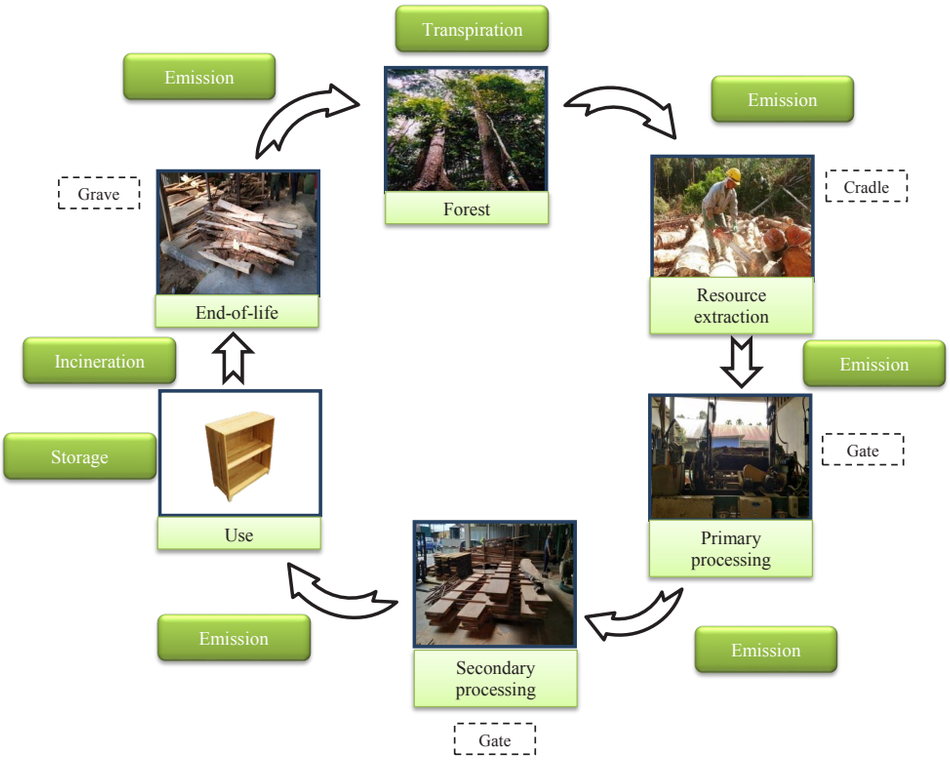

Figure 2 The cradle-to-grave life cycle stages associated with timber industry

Basically, forest absorbs carbon from the atmosphere. When trees are harvested for industrial purposes, part of the carbon remains sequestered in harvested logs, during the physical breakdown of wood and during its application. Carbon stored in wood products are released slowly in the landfill or immediately by combustion at the end of their life cycle. Carbon recycle between the forest and the atmosphere is called as carbon neutral (Figure 3).

Timber industry is regarded crucially important for the global carbon cycle. Yet, the wood processing and transportation activities produce 'new carbon' (Figure 3). The emission of CO_2 is hardly to be avoided as a result of energy consumption during these activities. Fuels, especially fossil type are used in timber processing activities, and they contain high content of carbon.

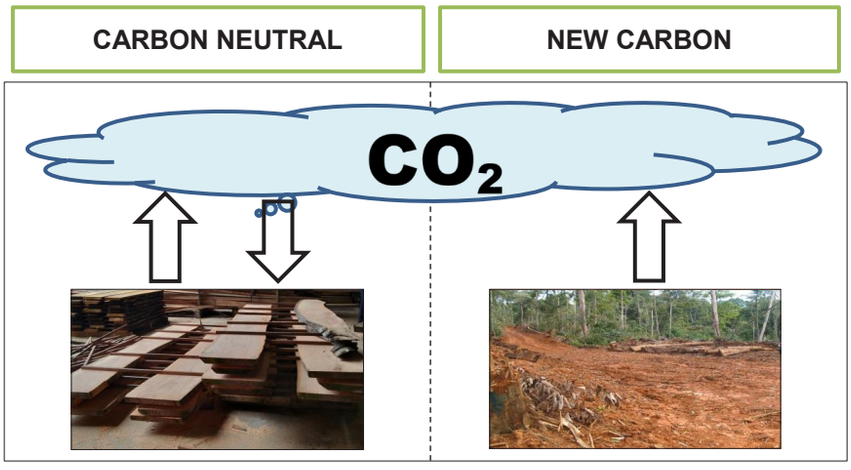

Figure 3 The differences between carbon neutral and new carbon

The assessment of environmental impacts generally entails to the whole life cycle. There are some LCA studies that focus only on cradle-to-gate assessment. The partial LCA observes from raw material extraction and ends with the production activity. The concept of cradle-to-gate gives an idea of the impact to the environment in order to make a product. As a matter of fact, the beauty of LCA is that it can be carried out section by section regardless of cradle-to-grave or cradle-to-gate situation.

Is LCA study about carbon only?

LCA is a multi-criteria analysis. This analytical tool takes into account several environmental emissions either from material under operation or discharge of pollutants throughout the life cycle. The potential environmental impacts is addressed on the basis of releases to the environment.

Why carbon is given priority in LCA?

Global warming has been the highest environmental impact profile. Anthropogenic emissions, particularly CO_2, methane (CH_4) and nitrogen oxide (N_2O), exacerbate global warming. It is noteworthy that the principal greenhouse gaseous (GHGs) emission is CO_2. Hence, reducing the emission of carbon has been a global significant attention, and LCA methodological framework has been an internationally accepted standardized method.

The release of 'new carbon' in the timber industry can be seen from:

- Emission from purchased electricity
  The timber industry use electricity for production activity. The primary source for electrical energy consumption in the timber industry is fossil fuels. The contents of fossil fuels comprise of carbon, sulphur, nitrogen and their compounds. Conventional power station burn fossil fuels to produce off-site electricity, resulting in the release of these contents to the environment.

- Emission from fuel sources
  Fuel sources such as petrol and diesel are used in the timber industry for logging operations, transportation and kiln drying activity. The combustion of fuel sources produces on-site thermal energy, and emits the content to the environment.

- Disposal at landfill
  Wood loss occur at each step of the production chain as carbon loss. These wood are used as energy generation, panel products production and pulp and paper industry. The disposal of wood waste to landfill create environmental concern. Landfilled wood waste release carbon in the form of CH_4 to the environment, due to anaerobic condition. It is to be noted that CH_4 is 21 times more potent than CO_2 as a GHGs.

LCA METHODOLOGICAL FRAMEWORK

The methodological framework of LCA is divided into four phases: (1) goal and scope definition, (2) life cycle inventory (LCI), (3) life cycle impact assessment (LCIA) and (4) life cycle interpretation, as shown in Figure 4.

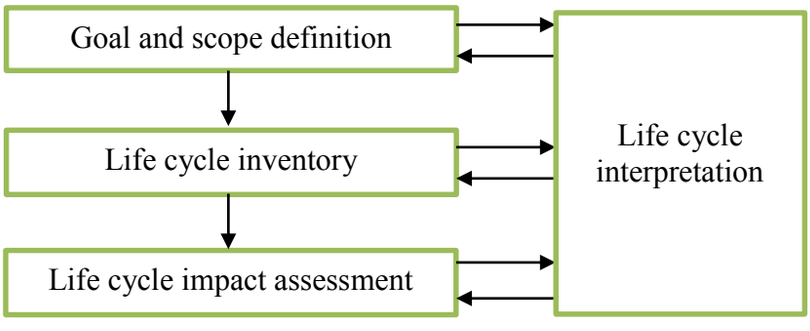

Figure 4 The phases of life cycle assessment

Phase 1: Goal and Scope Definition

The goal and scope definition phase is the structure of LCA study. This phase defines the purpose of the study and set up the methodological framework for the entire process. Every decision made in this phase will give impact on how to carry out the study. The first phase of LCA is regarded as the most important in view of all aspects that are defined here.

What aspects must be addressed in goal definition?

- **Purpose of study**
  It is to explain the reasons for conducting LCA study.

- **Intended application**
  The intended applications are product improvement, decision making, marketing or selection of environmental performance indicators.

- **Intended audience**
  It is to whom the LCA study are intended to be relayed.

- **Comparative analysis**
  It is to determine if the assessment is used for comparison purpose with alternative product.

What aspects must be addressed in scope definition?

- **Functional unit**
  It is the quantitative description of the studied product. It is used as a reference and also comparison with alternative products.

- **System boundary**
  A flow diagram showing the studied activities/processes, inputs, outputs and emission to the environment, see Figure 5.

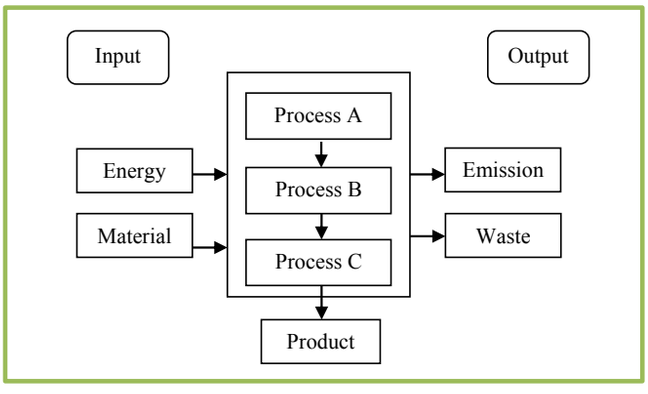

Figure 5 The system boundary

- **Allocation**
  It is the partitioning of the environmental burdens among the final products

- **Data quality requirements**
  The following aspects related to data quality:
  - Time-related coverage - Duration of data
  - Geographical coverage – Geographical area from which data shall be collected
  - Technology coverage – Current technology
  - Types of data - Primary data and secondary data
  - Sources of data – Identify if data is from measurement, calculation or estimation
  - Completeness – No gap in method and data
  - Representativeness, consistency, reproducibility – To check if method and data are representative, consistent and whether it can be reproduced
  - Precision – Measure the variability of data

Phase 2: Life Cycle Inventory (LCI)

Life cycle inventory (LCI) indicates the data collection of the inputs (material, energy and water) and outputs flow (final product, co-product, and environmental releases to land, air and water) within a product system (Finnveden et al. 2009). A complete LCI comprises of all phases in the life cycle stages. The inventory assessment for timber industry is a complex study as each life cycle stage may comprise of different types of activities. Therefore, the data collection for timber industry is implied on the basis of a series of its activities. Each activity within the product system is divided into several units of individual processes, to detail the identification of the inputs and outputs.

Phase 3: Life Cycle Impact Assessment (LCIA)

The result from the inventory study is not well defined since it does not reflect the impacts to the environment. Hence, it draws into unsupported conclusions. Life cycle impact assessment (LCIA) is a phase to evaluate the potential environmental impacts from the inventory study. The process to conduct the LCIA phase is briefly described in Table 2.

Table 2 Descriptions of LCIA method

LCIA sub-steps	Descriptions
	Compulsory steps
Selection of impact categories	The selection of impact categories reflects the overall of LCA study. This step is part of the goal and scope definition phase, as the direction for data collection process.
Classification	The inventory study consists of several environmental emissions. Classification step assigns the selected emissions into the selected impact categories.
Characterization	Characterization step transforms the environmental emissions which have been classified earlier into the respective impact categories by using an equivalency factor known as 'potential'.
	Optional steps
Normalization	This step transform the indicator results of different impact categories into a single format for comparison purpose.
Grouping	Grouping involves sorting the indicators on a nominal basis or by a ranking system.
Weighting	Converting the normalized result of each of the impact categories using a weighting factor to observe the most important potential impacts.

Phase 4: Life Cycle Interpretation

Life cycle interpretation is a technique to identify, quantify, check and explains thoroughly the results from the life cycle study. This final phase of LCA reviews and revises the scope of the study and followed by analysis of the results from the inventory study and environmental impact assessments. The point is to assure the confidence level of the life cycle results in a complete, fair and accurate manner (Finnveden et al. 2009).

APPLICATIONS OF LCA IN TIMBER INDUSTRY

The coverage of LCA study on timber industry will provide with reliable information on the environmental aspects and potential environmental impacts. Hence, life cycle concept may change the thinking in looking at environmental issues in the timber industry. The applications are shown in Figure 6.

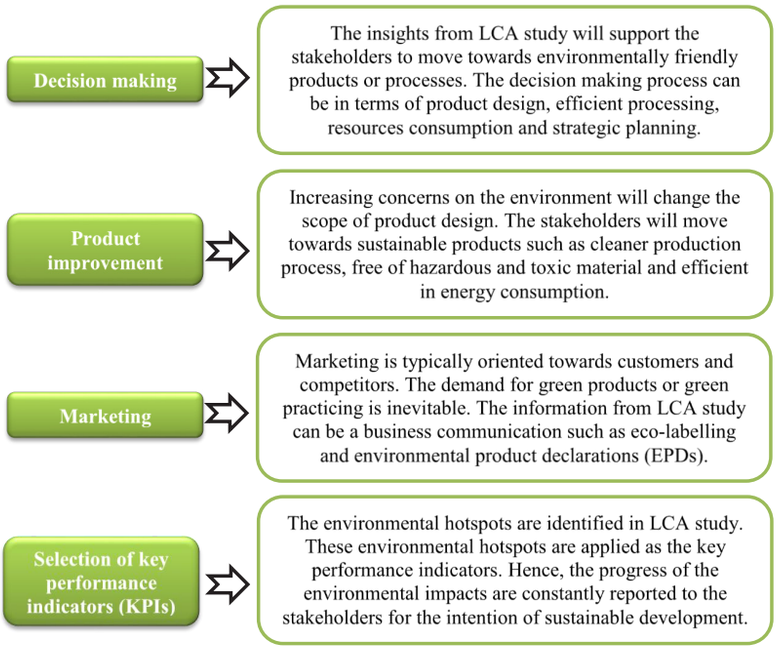

Figure 6 Applications of LCA in timber industry

CONCLUSION

LCA is a holistic method to assess the environmental aspects and potential environmental impacts of products. The insights from the LCA study will provide a quantitative basis for timber industry in which the stakeholders can make an environmentally favourable decision in material choice of wood products and optimization in processing activities.

REFERENCES

Bergman RD & Bowe SA. (2012). Life cycle inventory of manufacturing hardwood lumber in Southeastern US. *Wood and Fiber Science:* 44(1): 71–84.

Bergman R, Puettmann M, Taylor A & Skog KE. (2014). The carbon impacts of wood products. *Forest Products Journal:* 64(7/8):220–231.

Eshun JF, Potting J & Leemans R. (2010). Inventory analysis of the timber industry in Ghana. *The international Journal of Life Cycle Assessment*: 15(7): 715–725.

Finnveden G, Hauschild MZ, Ekvall T, Guinée J, Heijungs R, Hellweg S, Koehler A, Pennington D & Suh S. (2009). Recent developments in life cycle assessment. *Journal of Environmental Management*: 91(1): 1–21.

Guinée JB, Zamagni A, Masoni P, Buonamici R, Ekvall T & Rydberg T. (2011). Life cycle assessment: Past, present, and future. *Environmental Science Technology*: 45(1): 90–96.

Meil J, Wilson J, O'Connor J & Dangerfield J. (2007). An assessment of wood product processing technology advancements between CORRIM I and II studies. *Forest Products Journal*: 57(7/8): 83–89.

MTC. (2017). Malaysia Forest and environment facts & figures. Malaysian Timber Council. http://www.mtc.com.my/images/cms/MTC_Fact_Sheet.pdf

Wood, with its potential as carbon storage and lower embodied energy, is widely used for different purposes. However, the production or activities associated to products' life cycle in the timber industry consequently impacts the environment. The issues are inevitable in view that environmental issues are global concerns. The concept of life cycle assessment (LCA) is currently being applied in timber industry to assess the potential environmental impacts of product throughout its life cycle. The basic of LCA concept in the timber industry is briefly explained in this paper.

Series Editor : Mohamad Omar MK
Managing Editor : Vimala S
Typesetter : Rohayu Y

Set in Times New Roman 11

Printed by Publications Branch, Forest Research Institute Malaysia
52109 Kepong, Selangor