Pertanika J. Soc. Sci. & Hum. 22 (2): 335 - 347 (2014)

PERTANIKA JOURNALS

SOCIAL SCIENCES & HUMANITIES

Journal homepage: http://www.pertanika.upm.edu.my/

*Review Article*

# Challenges and Possible Drivers of LCA Implementation in Small and Medium Enterprises (SMEs) in Malaysia: A Review

**Chai Tew Ang, Norhashimah Morad* and Norli Ismail**

*Environmental Technology Division, School of Industrial Technology, Universiti Sains Malaysia, 11800 Minden, Penang, Malaysia.*

## ABSTRACT

Small and Medium Enterprises (SMEs) play a vital role in Malaysian economy. They are considered to be the backbone of industrial development in the country. However, the developments, challenges and prospects of SMEs in accepting the life cycle thinking perspectives have not been investigated thoroughly. This paper discusses the Life Cycle Assessment (LCA) related to developments in Malaysia and identifies the SMEs challenges during implementation of LCA based on publications and self-experience in conducting the LCA studies. There are a total of five main challenges of LCA implementation in SMEs; lack of awareness and participation, lack of government assistance and directive, short life-span of SMEs and the constraints on Malaysian SMEs. In addition, a possible driver of LCA implementation is the development of national life cycle inventory database which may reduce the cost and time of LCA data collection, and promote the implementation of LCA in Malaysian SMEs in a comprehensive and systematic manner.

*Keywords:* Small and Medium Enterprises (SMEs), Life cycle thinking, Life Cycle Assessment (LCA)

## INTRODUCTION

Life Cycle Thinking (LCT) is described as a concept in which we become mindful of how our activities and our use of products affect the environment, and our evaluation of the impact to the environment is holistic in nature, where we consider the impact from the raw material extraction, material processing, transportation, distribution,

ARTICLE INFO

*Article history:*
Received: 2 July 2012
Accepted: 28 August 2013

*E-mail addresses*:
carol.ang8@gmail.com (Chai Tew Ang),
nhashima@usm.my (Norhashimah Morad),
norlii@usm.my (Norli Ismail)
* Corresponding author

ISSN: 0128-7702 

consumption, re-use/recycling, and disposal (Wikipedia, 2013). Life cycle approach helps to avoid shifting the problems from one life cycle stage to another, from one geographical area to another and from one environmental medium such as (air, water and soil) to another (UNEP, 2004). In this new era, life cycle thinking is becoming increasingly fundamental in the development of key environmental policies around the world, It is used to form an array of decision making processes in business (EC-JRC, 2010). Environmental standards and regulations in industrialized countries can have significant impacts on the market access of developing countries. The fear in many developing countries has the fear that stricter product standards in the markets of developed countries will act as trade barriers to their exports. In business sustainability perspective, an eco-friendly with lifecycle thinking designed product or process will help businesses increase their profits and competitiveness while reducing their impacts on the environment.

Life Cycle Assessment (LCA) is a decision support tool in line with the concept of life cycle thinking. It is an analytical tool to systematicallyevaluate the potential environmental aspects of a product or service system through all stages of its life cycle (UNEP, 2004). LCA can also be defined as a method of inventoring, assessing and interpreting environmental interventions caused by products and product systems through their life cycle (Petterson & Hertwich, 2008). The International Organization for Standardization (ISO) defines LCA as "Compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle." (ISO14040: 1997).

LCA was developed from a merely energy analysis to a comprehensive environmental burden analysis in the 1970s. Full-fledged life cycle impact assessment and life cycle costing models were introduced in the 1980s and 1990s. Social-LCA and particularly consequential LCA has gained ground in the first decade of the 21$^{st}$ century. Many of the more recent developments have been initiated to broaden traditional environmental LCA to a more comprehensive Life Cycle Sustainability Analysis (LCSA) (Guinee *et al*. 2011).

In research and development, the drastic increase in the number of LCA related studies is not only observed in Europe and the US, but also in Asian countries like Japan and Thailand (Curran, 2011). Among reasons for the increase are the importance placed on the key drivers of environmental management concepts such as the ecolabelling scheme and other product standards requirements which are modeled from LCA framework and concept (Chen, 2011). Malaysian industries, especially the SMEs, are now facing a great challenge in LCA implementation. As the backbone of industrial development, SMEs has contributed 99.2% of the entire business formations in Malaysia in 2010 (SME Annual Report, 2011/2012). In order for SMEs to be equipped for globalization, it is important for the SMES to understand

the concept of LCT, so that they will be well ahead in understanding the shift towards green products amongst consumers. Although LCA is not a requirement in doing business, SMEs should be encouraged to be receptive towards LCA implementation. Therefore, it is important to conduct a research study focusing on SMEs' challenges in implementing LCA.

This paper, discusses the current development associated to LCA in Malaysia and further investigates SMEs challenges and issues in implementation of LCA. It also identifies a few possible drivers towards the success of LCA implementation in Malaysia. The analysis in this paper is based on the informal interview, authors' own experience in conducting LCA studies in Malaysis, and reviews of relevant publications.

*Life Cycle Assessment (LCA)*

LCA has been receiving considerable attention from individuals in the environmental field since 1990 (Curran, 1996). LCA is a tool that is used to assess the environmental impact and resources used throughout the life cycle of a product, for example from raw material acquisition, via production and use phases, to waste management. Each stage of the life cycle of any product or event is linked to other secondary stages, each of them may further be linked to other stages, and so on. Covering the entire associated steps, the boundary may go on expanding to become too complex to be analyzed. Therefore, selection of cradle to grave should be done appropriately depending on the objective of the assessment as well as the availability of data (Divya *et al*. 2010). For instance, the review done by Finnveden *et al.* distinguishes between the two types of methods for LCA that ie. attributional LCA and consequential LCA. Attributional LCA is defined by its focus on describing the environmentally relevant physical flows to and from a life cycle and its subsystems. While, Consequential LCA is defined by its aim to describe how environmentally relevant flows will change in response to possible decisions (Curran *et al.* 2005).

*Malaysian Small and Medium Enterprises (SMEs)*

Generally, SMEs are defined into three broad categories based on the National Small and Medium Enterprises Development Council (2005) definitions of SMEs:

1. Primary agriculture;
2. Manufacturing(including Agro-base) and manufacturing-related services; and
3. Services sectors(including Information & Communication Technology)

SMEs in Malaysia can also be grouped into three categories according to sizes: Micro, Small or Medium. These groupings are decided either based on the number of people employed or the business total sales as well as revenue generated in a year (SME, 2008). In general, this paper covers all SMEs categories in the manufacturing sector. As reported in the SMEs Annual Report 2010/2011, SMEs account for 99.2% of total business establishments and 96.5% (39,436 companies) of all enterprises in

the manufacturing sector. The majority is engaged in the food and beverages sub-sector (32.5%); then followed by chemicals and chemical products (15.6%), rubber and plastic products (10.3%) and fabricated metal products (6.6%). These industries accounted for 79.0% of total SMEs output (SMI Business Directory, 2009). In summary, SMEs make a significant contribution to the Malaysian domestic economy.

## OVERVIEW OF LCA DEVELOPMENT IN MALAYSIA

The industrial application of LCA vary, as each SMEs has its own unique culture driven by business strategy, competitive landscape, organization structure, and many other internal and external factors (ACLCA, 2013). Ultimately, LCA applications give impact towards a company's products and operations.

For instance, LCA has emerged as a valuable decision-support tool for both policy-makers and industry in assessing the cradle-to-grave impacts of a product or process. Three forces are driving this evolution (GDRC, 2013). First, government regulations are moving in the direction of "life-cycle accountability", the notion that a manufacturer is responsible not only for direct production impacts, but also for impacts associated with product inputs, use, transport, and disposal. For example, Malaysia has adopted the European Union Restriction of Hazardous Substances Directive (RoHS Directive). The Department of Environment, Malaysia has drafted the proposed legislation (Pemudah, 2013). Second, business is participating in voluntary initiatives which contain LCA and product stewardship components. It include, ISO 14000 and the Eco-labelling-Scheme, both seek to foster continuous improvement through better environmental management systems (SIRIM, 2008). Third, environmental "preferability" has emerged as a criterion in both consumer markets and government procurement guidelines (GIPC, 2011). These developments collectively have placed LCA in a central role as a tool for identifying cradle-to-grave impacts of both products and the materials used for manufacturing.

In addition, LCA is also important in setting and supporting related strategies to help reduce wastes, emissions and the consumption of resources that are attributable to the provision and consumption of goods and services. It is important for all countries to promote sustainable consumption and production patterns, with the developed countries taking the lead (SIRIM, 2008). The following section outlines some of the LCA related activities, especially in SMEs, within our nation.

### *Driving a Greener Industry*

The government in Malaysia has given the mandate to Standards and Industrial Research Institute of Malaysia (SIRIM) to spearhead the National Life Cycle Database and champion various activities related to LCA. SIRIM's The Environment & Bioprocess Technology Centre of SIRIM in partnership with Thailand Environment Institute and renowned European organizations, IZM

Fraunhofer of Germany and CiTQ of Spain has implemented a project on sustainable production and consumption. Under the project funded by the European Union (EU), four Malaysian SMEs and three SMEs from Thailand have been identified to establish best practices in sustainable production and consumption. electrical and electronics sector, the most common sector for the mass production of consumer goods, have been selected (SIRIM, 2008).

In addition, the Seberang Jaya Municipal Town Council (MPSP) of the Penang State Government has introduced the green industry activity. The town council organized a Penang Green Industry Practices Conference for the first time in July 2011. the MPSP Penang Green Industry Practices Working Group conducted the conference with the involvement of all major SMEs, factories and NGOs in Penang. The key goal was to organize a series of workshops and pave the way for the standardization of green practices for industries managed by the Government. For instance, MPSP Penang Green Industry Practices Working Group in partnership with Universiti Sains Malaysia (USM), offers the Penang Green Award, the most prestigious environmental award in Penang. It aims to encourage businesses, factories and organizations to adopt green management (GIPC, 2011).

*Development of National Life Cycle Inventory (LCI) database*

In general, LCA studies require extensive time and incur high cost due to data collection. Therefore, most LCAs are developed using a combination of data sources, namely a primary source and a secondary source. The development of an LCI database helps to accelerate data collection during the LCA study.

We have soft-launched our first National LCI database in Malaysia on 15 Dec 2010 (SIRIM, 2010). Nine working groups have been appointed to take the lead in conducting gate-to-gate LCI database development (The National LCA Project, 2011). To enhance the National database development, Global Information System (GIS) shall be incorporated for capturing, stocking, checking, integrating, manipulating, analyzing and displaying data which are spatially referenced to the earth. In the simplest terms, GIS is the merging of map production and database technology (Liu, 2011). With the availability of National LCI database, it may help SMEs to overcome financing and time constraints in terms of data collection activities.

*Green Procurement*

The Prime Minister of Malaysia has launched The National Green Technology Policy on 24 July 2009. This policy is concerned with the development and application of products, equipment and systems used to conserve the natural environment and resources. Aligned with the sustainable approaches in LCA, this policy is built on four pillars: Energy, Environment, Economy and Social. there is collaboration among the Ministry of Finance, the Ministry of Energy, Green Technology and Water (KeTTHA), Malaysian Green Technology Corporation

and SIRIM under the green procurement activities. Among the proposed activities that are related to the manufacturing sector is the development of the National Eco-Lablling Prograe for Products and Services. Implementation of LCA study, development of an information framework and the National LCI database are the key drivers to the success of our National Ecolabeling Program (Ahmad, 2010). GreenTech Malaysia also launched The GreenTAG endorsement label at International Greentech and Eco products exhibition and conference Malaysia (IGEM) 2012 to encourage and support manufacturers' intention to scale-up to green certification. GreenTAG, falls under the MyHijau labeling umbrella, is a temporary endorsement programme that assists SMEs or producers of green products to achieve the MyHijau certification for their goods and services. SMEs receive certification incentives such as free training and consultancy. Products with GreenTAG is listed in the MyHijau Directory and given the opportunities to participate in Malaysia's Green Procurement Program (Green Prospect Asia, 2012)

*Carbon Trading*

The significant role of LCA application is visible in carbon trading activities. Considering the very first step of carbon trading is to identify the total carbon burden and emissions of certain processes or products before the carbon is used to trade in carbon trading activities. Despite carbon trading being relatively new in Malaysia, a biomass project in Sabah, a state in East Malaysia, is actually the first in the world to be awarded a Certified Emission Reductions (CERs) by the United Nation Executive Board of Clean Development Mechanism (CDM) (Oh & Chua, 2010). As of March 2009, based on data released by the United Nations Environment Programme (UNEP) resource center, there were a total of 4660 future CDM projects registered worldwide, with Malaysia having 156 projects or 4% of the listed projects in the pipeline (Climate Avenue, 2011). Biomass Sustainable Production Initiative set in motion with the EU-Malaysia Biomass Entrepreneurs Nurturing Programe in 201 (EUM-BENP). Under this initiative, 45 Malaysian biomass SMEs have been selected to participate with the aim of improving environmental and business performance via coaching and training services (Biomass-SP, 2012).

*Green Partnership Project*

Considering Malaysia is a developing country, assistance from a developed country in sharing their expertise and experiences in LCA guidance would be helpful in steering this country towards a greater awareness in LCA. In 2008, the Japan External Trade Organization (JETRO) provided valuable technical advice to SIRIM in the establishment of the Malaysian Life Cycle Assessment system (JETRO, 2008). sIn addition, JETRO has also provided technical support and instruction to Malaysia through workshops. Recently, K-one was awarded 2004 Enterprise 50 Award by SMIDEC. The award honors the top 50 SMEs in Malaysia. K-one is also certified as Sony Green Partner

by Sony Corporation, Japan, in recognition of its environmentally-friendly design and manufacturing processes in year 2005 (K-one, 2013).

## SMES CHALLENGES IN IMPLEMENTATION OG LCA

The following are SMEs challenges in implementation of LCA.

### *Lack of Awareness and Participation*

The development of the National LCI database needs the cooperation of the industrial community. However, the industrial community still lack in their willingness and participation in providing data needed for an audit or a survey. It might be due to insufficient knowledge, or the inability to answer the question, or pure lack of interest in the whole process of data collection. SMEs and start-ups are often discouraged from focusing on anything other than time-to-market, time-to-cash, and core competencies (Ahmad, 2010). The involvement of the manufacturing sector in LCA implementation is still at its infancy stage due to the lack of assistance or guidance from those with LCA expertise. Specifically, the complexity of LCA methodology, difficulties with assessments and interpretation might be tha factor in this lack of enthusiasm to participate.

### *Challenges in Data Collection*

Inadequate data and information has been identified as the primary obstacle for LCA (Keoleian, 1993). The inventory phase usually takes a great deal of time and effort and mistakes are easily made. Besides, the data is often inconsistent and not directly applicable due to different goals and its varied scope. In some cases, results are generalized improperly. As one collects, models, calculates and estimates inventory data, many decision points are encountered and many technical assumptions about the data must be made. To get to a level of consistent practice, these decision points need to be clearly identified, and possibly categorized so that more uniform rules can be applied (Curran, 2003).

The development of the National LCI database is an important step to partially solve the obstacles along the path of data collection activity. For instance, the LCA activities in Japan, Korea, China, Chinese Taipei and Australia have been very active. Their LCA activities include the standardization of methodology, database development, applied LCA research, software development and LCA information-sharing and networking (Zakaria*et al.* 1999).

Both cost and time constraints also limit the practice of LCA (Sullivan & Ehrenfeld, 1993; White & Shapiro, 1993). Small companies are unlikely to be able to afford to specialize in LCA or sponsor studies externally. The majority of SMEs in Malaysia face problems in applying eco-design tools, yet these form an integral element in LCA. This is attributed to the lack of information and data from the upstream and downstream of the supply chains. The inadequacy of LCA data and information in Malaysian SMEs might result in the inability of the industry to

compete well in the globalized world should accessibility to LCA data of its product be made a requirement to do business.

*Lack of Government Assistance and Directives*

The support and commitment, particularly financial resources, from the government is crucial for local LCA development. One of the characteristics of the successful LCA activities in Japan, Korea, China, Chinese Taipei and Australia is that the governments play an active role in the promotion and implementation of LCA activities and projects. The situation in the aforementioned countries is in contrast with those in Kazakhstan and Uganda in which LCA activities are non-existent, even though there is recognition of the potential use of LCA and its benefits. It is postulated that the mere existence of groups' interest in LCA development is insufficient for the advancement of LCA. The capacity to successfully implement LCA does exist in these two countries. Due to the lack of support from respective governments and the absence of institutions capable of practicing and promoting LCA, the concept has not been developed in those countries (Curran, 2003).

There is actually no government enforcement for the implementation of LCA although there are numerous LCA-related activities in Malaysia such as seminars and collaboration projects run by developed countries and funded by the Malaysian government to encourage the implementation of LCA in the manufacturing sector.

*Short Life-Span of SMEs*

Another main reason of the ineffectiveness in implementation of LCA in SMEs especially in the manufacturing sector is the short life-span of SMEs. Based on studies done, it is observed that the average life-span of an SME is only five years. Jones (2011) and Moya (2009) have pointed out that: "The Small Business Administration (SBA) keeps the statistics on business failures and claims that more than half of the new businesses will disappear in the first five years". Therefore, the collected LCA sample data from these SMEs may no longer be relevant after a few years. This is another reason why LCA involvement is less popular in the manufacturing sector.

*Constraints on Malaysian SMEs*

SMEs in many countries face a myriad of challenges. Apart from their contribution to exports, employment and economic growth, there is a wide recognition in the literature about the challenges and barriers faced by Malaysian SME (Saleh & Ndubisi, 2006). These obstacles prevent them from growing further and set them in a critical position when facing new challenges arising from globalization, liberalization as well as the extensive changes in technology and infrastructure. It has been documented that the barriers faced by SMEs in Malaysia do in fact undermine their performance (Stuti, 2005; Wang, 2003; SMIDEC, 2002; Moha, 1999). In addition, the report highlights many challenges faced by SMEs in a globalised environment, for example lack of financing, low productivity, lack of

managerial capabilities, inaccessibility to management and technology, heavy regulatory burdens, and many others (Matthews & Fink, 1994).

## POSSIBLE DRIVERS TOWARDS THE IMPLEMENTATION OF LCA IN MALAYSIAN SMES

The greening of the economy is not a new task; it is a challenge that a lot of tasks still have to be done (Frankl & Rubik, 2000). Awareness is the most important aspect that has to be considered to ensure that policies are implemented in the manufacturing sector. We have to ensure that life cycle thinking ideology is cultured among all SMEs so that they begin to function with "green" in mind. LCA is yet to be used as a routine tool in assessing the environmental aspects of product innovation. At present, it is employed retrospectively instead of prospectively.

The cost of the implementation of LCA is another main concern. In general, the most important barrier for environmentally-friendly innovations seems to be the investment costs, for example the high risk involved in committing capital to unproven technology (Katajajuuri *et al.* 2010). Therefore, providing a comprehensive assistance package comprising financial assistance and advisory services to the local manufacturing sector, especially SMEs, would be a welcome incentive for them to incorporate and implement LCA.

If the LCA concepts are too complicated to be understood by stakeholders in SMEs, then systematic environmental management based on simplified LCA approaches must be applied. If stakeholders in SMEs find it too complicated to comprehend LCA concepts, systematic environmental management based on simplified LCA approaches must be applied. In this way win-win solutions, both environmental improvements and economic can reap the benefits (Rebitzer *et al.* 2004).

LCA is a very data intensive tool; therefore, developing our National LCI database is an important step towards successful LCA implementation among the SMEs in the manufacturing sector in Malaysia. The initiatives from the various industrial sectors are vital in the development of their own industrial product database (Rebitzer *et al.* 2004). The Association of Plastics Manufacturers in Europe (APME) is a worthy example of making data available to the public (Saleh & Ndubusi, 2006). SimaPro and Gabi are the most popular software used for LCA. The easy accessibility of these softwares by the governing SMEs associations would help to accelerate the evaluation processes of LCA study in SMEs.

The short life-span of SMEs might be another obstacle for SMEs to implement LCA since the result of assessment is only applicable in very short duration. However, with the availability of our own National LCI database, the data collection period for any LCA study will be considerably shortened. Ultimately, the National LCI database will create a better communication platform for those in the manufacturing sector especially in SMEs. The government

may step in to provide support schemes or incentives for SMEs participating in sharing their data for the development of the National LCI database even though it is just a short life-span inventory data.

Legislation has been the traditional way to control industrial activities. The aim of environmental law is to foresee and control harmful environmental impacts. There are a number of global environmental regulations that prohibit the use of certain substancesor set emission limits and control of safe recycling at a products end-of-life, for example RoHS Directive, Waste Electrical and Electronic Equipment (WEEE) Directive and Energy-using Products (EuP) Directive (Matthews, 2007). The RoHS Directive in Malaysia is no longer a strange directive to most of the multinational companies in the manufacturing sector (SIRIM, 2007). Their products need to comply with this directive prior to exportation to developed countries. Therefore, the implementation of LCA would be a success if such legislations were implemented effectively.

Other drivers, like corporate social responsibility, stakeholder pressure, non-governmental organizations and pressure from the general public, will also affect the final decision. Such pressures have increasingly led SMEs to accept the challenge in meeting the environmental standards.

The survey conducted by Ang at Malaysian Packaging Industries in 2005 indicates that *concern of the top management for the environment* is the main motivating factor of the ISO 14001 standards implementation (Ang, 2005). Similar results are also shown in the study performed by Goh (2010); the decision from the top management of Malaysian SMEs is the most influential motivating factor towards the certification of ISO14001. In addition, key advisors are a critical factor for SMEs. The sustained presence of directors or board members, with adeqate awareness level, ability to develop and implement environmental policies and life cycle applications for start-ups will play a significant role in this aspect (Rebitzer *et al.* 2004). Ideally, the main driver for implementation of LCAs should further improve a company's own products and processes building a strong interaction with design or development and manufacturing, where necessary.

## CONCLUSION

SMEs in Malaysia remain as important contributors to the economic growth of the country. The life cycle thinking ideology should be cultured in all SMEs in order to promote the implementation of LCA in Malaysia. In this review, five main challenges of LCA implementation in SMEs are identified, namely lack of awareness and participation, lack of governmental assistance and directive, short life-span of SMEs and the constraints on Malaysian SMEs. In addition, a possible driver of LCA implementation is the development of national life cycle inventory database which may reduce the cost and time of LCA data collection and help to promote the implementation of LCA in Malaysian

SMEs in a comprehensive and systematic manner. The technical support from the developed countries and financial assistance and legislation enforcement from Malaysian authorities will help driving SMEs towards achieving the LCA implementation, even though the LCA implementation in Malaysian SMEs is still at a very early stage.

## ACKNOWLEDGEMENTS

The authors gratefully acknowledge assistance in the form of Postgraduate Research Grant Scheme and Postgraduate Fellowship from Institute of Postgraduate Studies, Universiti Sains Malaysia, to fund this research(Grant No: 1001/PTEKIND/843107).

## REFERENCES

ACLCA. (2013). *Operationalizing LCA within Industry*. American Center for Life Cycle Assessment. Retrieved April 21, 2013, from http://www.lcacenter.org/LCA9/special/Operationalizing-LCA.html

Ahmad. Z. I. 2010. *Development of National Green Technology*.GreenTech Malaysia. 26 April 2010. Malaysian Green Technology Corporation. Retrieved Nov 10, 2011, from http://www.scribd.com/doc/47975925/Green-Tech-KeTTHA

Ang, C. T. (2005). *Simplified Life Cycle Assessment in Environmental Management: Case Study in Packaging Industry*. (Master Dissertation).( Universiti Sains Malaysia),. ().

Biomass-SP. (2012). *EU-Asia Biomass Best Practices & Business Partnering Conference 2012*. 7-10 May 2012, Putra World Trade Center: Kuala Lumpur. Retrieved April 23, 2012, from http://biomass-sp.net/wp-content/uploads/2011/12/Press-Release-_English-Version_-9.12.pdf

Chen, S.S. (2011). *National Eco-LabellingProgramme.* Green Technology Seminar.Kuala Lumpur: MATRADE

Climate Avenue. (2011). *Carbon credit explained*. Retrieved Nov 8, 2011, from http://climateavenue.com/cdm.carbon.cred.index.htm

Curran, M. A. 1996. *Environmental life-cycle assessment*. USA: McGraw-Hill.

Curran, M. A. 2003. *Background document.*Workshop on life cycle inventory databases. Retrieved Sep 5, 2009, from http://www.lcacenter.org/InLCA-LCM03/LCI-workshop.pdf

Curran, M. A. (2011). *Maintaining quality critical peer review (CPR) as the demand for life cycle assessments increases*. LCM 2011. Berlin: 28-31 August 2011.Session Critical Review and Verification of LCA.

Curran, M. A., Mann, M., & Norris, G. (2005). The international workshop on electricity data for life cycle inventories. *J. Cleaner Prod.*, *13*(8), 853–862.

Divya P., Madhoolika, A., & Jai, S., P. (2010). Carbon footprint: current methods of estimation. *Environmental Monitoring and Assessment, 178*(1), 135-160.

EC-JRC. (2010). *Our Thinking-Life Cycle Thinking*. European Commission-Joint Research Centre-Institute for Environment and Sustainability. Retrieved May 7, 2013, from http://lct.jrc.ec.europa.eu/

Finnveden, G., Hauschild, M. H., Ekvall, T., Guinee, J., Heijungs, R., Hellweg, S., Koehler, A., Pennington, D., & Suh, S. (2009). Recent developments in Life Cycle Assessment.*Journal of Environmental Management, 91*, 1–21

Frankl, P., & Rubik, F. (2000). *Life cycle assessment in industry and business-:adoption patterns, applications and implications*. Germany: Springer

GIPC. (2011).*Green Industry Practices Conference 2011*.Penang (MPSP) Green Industry Practices Working Group. Retrieved August 20, 2011, from http://gipwg.org/eng/?p=53

GRDC (2013). *Defining Life Cycle Assessment.*The Global Research and Development Center. Retrieved April 21, 2013, from http://www.gdrc.org/uem/lca/lca-define.htm

Green Prospect Asia. 2012. *Malaysia Launches Green Labeling Scheme*. December Issue 2012. Retrieved April 24, 2013, from http://www.greenprospectsasia.com/content/malaysia-launches-green-labelling-scheme

Goh, Y. N. (2010). *Factor influencing ISO14001 Environmental Management Systems on SMEs Performance.* (Doctor of Philosophy Dissertation, UniversitiSains Malaysia).

Guinee, J. B., Heijungs, R., Huppes, G., Zamagni, A., Masoni, P., Buonamici, R., Ekvall, T., & Rydberg, T. (2011). Life cycle assessment: Past, present, and future. *Environmental Science and Technology*, *45*(1), 90-96.

ISO 14040. (1997). *Environmental Management: Life Cycle Assessment– Principles and framework.* International Organization for Standardization.

JETRO. (2008). *Green Partnership Program*. Retrieved Nov 13, 2011, from www.jetro.go.jp/malaysia/activities/gpp/

Jones, Noel. (2011). *SME's Life Cycle-Steps to failure or success*. Retrieved Nov 13, 2011, from www.moyak.com/papers/small-medium-enterprises.pdf

Katajajuuri, J.-M., Silvenius, F., Koivupuro, H.-K., Thun, R., Grönman, K., Soukka, R., Järvi-Kääriäinen, T., Ollila, M., Kuisma, M., Miettinen, O.,Pitkänen, H., &Wessman, W. (2010). Preventing environmental impacts of products by proper packaging - Conclusions from LCA case studies as main rationale for packaging designer toolbox. *Proceedings of the 17th IAPRI World Conference on Packaging, Scientific Research Publishing*, USA: 480-483.

Keoleian, G. A. (1993). The application of life cycle assessment to design. *Journal of Cleaner Production, 1,* 3-4.

K-one. 2013. *Milestone and Achievements.* Retrieved April 24, 2013, from http://k-one.com/milestones_and_achievements.html

Liu, F., Wu, K., Shi, J., & Lu, C. (2010).Preliminary design of GIS-based LCA database. *Advanced Computer Theory and Engineering (ICACTE), 2010 3rd International Conference on 20-22 Aug, 2010*. Vol.1, pp. V1-6-V1-9

Moha, A.(1999). *Small and Medium Enterprises in Malaysia: Policy Issues and Challenges*, Vermont, Ashgate.

Matthews, H. S. (2007). Meeting the EuP directive: Life cycle assessment information sharing as opportunity for global compliance.*IEEE. International Symposium on Electronics and the Environment*. pp.155-158

Mason, Moya K. (2009). *Research on Small Businesses* Retrieved Aug 20, 2009, from http://www.moyak.com/papers/small-businessstatistics.html

Matthews, V., & Fink, P. (1994). Database generation for olefin feedstock and plastics.*Journal of Clean Production*, *1*, 173-180.

Oh, T. H., & Chua, S. C. (2010). Energy efficiency and carbon trading potential in Malaysia. *Renewable and sustainable energy reviews,* 14, 2095-2103.

Pemudah. (2013). *Restriction on Hazardous Substances*. Pasukan Petugas Khas Pemudahcara Perniagaan. Retrieved April 23, 2013, from http://www.pemudah.gov.my/sekatan-ke-atas-bahan-bahan-berbahaya [in Bahasa].

Pettersen, J., & Hertwich, E. (2008). Critical Review: Life Cycle Inventory Procedures for Long Term Release of Metals. *Environmental Science & Technology*, *42*(13), 4639-4647.

Rebitzer, G., Ekvall, T., Frischknecht, R., Hunkeler, D., Norris, G., Rydbergf, T., Schmidt, W. S., Suh, S., Weidema, B. P., & Pennington, D. W. (2004). Life cycle assessment Part 1: Framework, goal and scope definition, inventory analysis and applications. *Environment International, 30,* 701– 720.

Saleh, A. S., & Ndubisi, N. O. (2006). . *An* Evaluation of SMEs Development in Malaysia. *International Review of Business Research Papers, 2*(1), 1-14.

SIRIM. (2007). *Inspiration and Innovation for a better tomorrow. Standards* and Industrial *Research* Institute of Malaysia Annual Report.

SIRIM. (2008). *Driving a greener industry*. *Standards* and Industrial *Research* Institute of Malaysia Link Quarter 2 Report.

SIRIM. (2010). Malaysia Life Cycle Inventory Database (MY-LCID) launched. *Database propagates the use of Life Cycle Assessment (LCA) among the local industry. Standards* and Industrial *Research* Institute of Malaysia. Retrieved May 31. 2011, from http://www.sirim.my/news_popup.asp?id=107

SME Annual Report. (2008). *Rising to meet global challenges*. SME National Development Council.

SME Annual Report. (2011/2012). *Redefining the Future*. SME National Development Council.

SMI Business Directory. (2009). *Overview of SMIs/SMEs.*Retrieved Nov 19, 2011, from http://www.smibusinessdirectory.com.my/smisme-editorial/about-smisme/all-about-smisme/306-overview-of-smissmes-archive-2009.html

SMIDEC. (2002). *SMI Development Plan (2001–2005).*PercetakanNasional Malaysia Berhad, Kuala Lumpur.

Stuti, K. IAS. (2005). *Overcoming Barriers to Innovation for Indian SMEs*. Ministry Small Scale Industries, New Delhi, India.

Sullivan, M. S., & Ehrenfeld, J. R. (1993). *Total Qual. Environ. Manage.* Winter. pp. 1143

The National LCA Project. (2011). *Steering Committee and Project Structure. Standards* and Industrial *Research* Institute of Malaysia. Retrieved September 20, 2011, from http://lcamalaysia.sirim.my/steering_comm.asp

UNEP. (2004). *Why Take A Life Cycle Approach?* United Nations Publication. Retrieved May 10, 2012, from http://www.unep.fr/scp/publications/details.asp?id=DTI/0585/PA

Wang, S. D. (2003). The *Implications of E-Financing: Implications for SMEs.*Bulletin on Asia-Pacific Perspective 2003–2004, United Nations.

Wikipedia. (2013). *Life Cycle Thinking*. Retrieved May 19, 2013, from http://en.wikipedia.org/wiki/Life_Cycle_Thinking

White, A. L., & Shapiro, K. (1993). *Environmental ScienceTechnology, 27*(6), 1016.

Zakaria, Z., Hassan, M. H., & Awang, M. (1999). Current status and needs for life cycle assessment development in Asian Pacific Regions. *The International Journal of Life Cycle Assessment, 4*(4), 191-194.