INTERNATIONAL JOURNAL OF SUSTAINABLE CONSTRUCTION ENGINEERING AND TECHNOLOGY
VOL. 12 NO. 5 (2021) 116-124

IJSCET

http://publisher.uthm.edu.my/ojs/index.php/ijscet

ISSN : 2180-3242 e-ISSN : 2600-7959

International Journal of Sustainable Construction Engineering and Technology

Identification of the Challenges of Life Cycle Costing in GreenConstruction Projects in Malaysia

Mysarah Maisham[1], Hamimah Adnan[1*], Noor Akmal Adillah Ismail[1]

[1]Faculty of Architecture, Planning & Surveying,
Universiti Teknologi MARA, Shah Alam, 40450, MALAYSIA

*Corresponding Author

DOI: https://doi.org/10.30880/ijscet.2021.12.05.012
Received 19 October 2021; Accepted 31 December 2021; Available online 31 December 2021

Abstract: Concerns on the effect of construction industry to the environment has driven an increase in sustainable construction activities as well as green initiatives. Life cycle costing (LCC) which is a method of assessing the total cost of ownership of an asset or project has been commonly associated with sustainable-related studies and are used around the world for the last few decades. Even though many benefits have been associated with LCC, its implementation in construction industry is still limited, particularly in green construction projects. This paper aimed to identify the main challenges in implementing LCC in Malaysia's green construction projects. A quantitative approach via questionnaires survey was conducted on 200 respondents from various backgrounds, namely architects, quantity surveyors, engineers and other professionals typically would be involved in LCC preparation for green construction projects in Malaysia. The questionnaires were distributed to the respondents via traditional mail followed by e-mail as well as online platforms in order to increase the response rate. A total of fifty (50) completed and usable questionnaires were collected and analysed based on mean scores and ranking method. It was discovered that the main challenges of LCC in green construction projects were insufficient project or context specific data and difficulties in carrying out LCC calculations due to absent of proper LCC guidelines or framework. The findings serve as a valid point of reference for industry participants concerned with green developments to improve the LCC process and its adoption in Malaysia's green construction projects. Efforts must be taken to minimize or ease these challenges perhaps by formulating a framework or guideline specifically designed to address the challenges, thus improving the LCC process and encouraging its adoption in Malaysia which will ultimately contribute towards achieving the world's green construction agenda.

Keywords: Life cycle costing, challenges, green construction projects

1. Introduction

Construction industry is known to have a range of potential detrimental effects to the environment. Among others are the non-recycleable waste produced from construction activities, effect on greenhouse gas emissions from buildings' energy use, land use effect as urbanization increases, and building products' consequences to human health and indoor environment (Sharma et al, 2011; Hoseini et al, 2013; Munarim and Ghisi, 2016). These concerns caused an increase in the interest on a global scale in sustainable construction activities as well as green initiatives (Wang et al, 2014; Kibwami and Tutesigensi, 2016). In response to the world agenda for sustainable development, many countries have been gearing up its effort to operate in a greener mode by lowering the nation's carbon emissions, conserving energy and promoting the use of green technology and other green practices (Mohamed Bohari et al, 2015). Various mechanism are being

*Corresponding author:hamimah689@uitm.eu.my

introduced and practiced all around the world such as green procurement, green building or project certifications, and green product labelling (Mohamed Bohari et al, 2015; MGTC, 2019), which are all in line with United Nation's Sustainable Development Goals No.11. Apart from all these, one tool that has been frequently associated with sustainable-related studies is Life Cycle Costing (LCC) (Maisham et al, 2019).

Within the context of built environment, life cycle costing (LCC) is a technique used by project team to evaluate the project's anticipated economic performance throughout its life cycle from design stage, construction, operation and maintenance, up to its disposal (Boussabaine and Kirkham, 2004). It was first introduced in the U.S in the mid-1960s to assist the procurement of military equipment by the U.S Department of Defence (Atkinson, 1996). Since then LCC became a popular approach for decision-making among U.S. government agencies (Goh and Sun, 2015). Morever, ever since sustainable development became prominent at the beginning of 21st century, there has been an increase interest in LCC application especially in green construction projects. Among others, because the approach enables decision-makers to fully grasp the short-to-long term costs and benefits of the project, which is a vital economic information when making decisions (Miah et al, 2017). Nevertheless, previous studies have claimed that LCC implementation in the construction industry is still lacking (Higham et al 2015; Sesana and Salvalai, 2013). Although plenty of studies have been carried out on the area of LCC relevant to green construction practices or sustainable development (De Giacomo et al, 2019; Ahmad Jasmi et al, 2018; Dwaikat and Ali, 2018; Lim et al, 2018; Zuo et al, 2017; Higham et al, 2015), the current state of LCC in green construction projects in Malaysia is still at its infancy. Therefore, this paper aims to identify the main challenges in implementing LCC in green construction construction projects.

2. Life Cycle Costing in Green Projects

Since its first introduction, LCC has extended its application to many areas such as product design, buildings, transportation, and technologies (Eriksson et al, 2016; Ng et al 2014). The term 'life cycle costing' is used interchangeably with other terms such as 'life cycle cost analysis', 'whole life cost', and 'total cost assessment' (Shin and Cho, 2015; Mateus et al, 2013). RICS (2016) defined LCC as "a tool to assist in assessing the cost performance of construction work, aimed at facilitating choices where there are alternative means of achieving the client's objectives" and even allows same basis of comparison when these alternatives differ. Furthermore, LCC enables evaluation of a building's economic performance throughout its life cycle, from its initial planning and design to construction, operation and maintenance, refurbishment and finally, its demolition (Volkov et al 2014).

Green construction has become a necessity for the environmentally consious industry (Hwang, 2018). Construction of green buildings is part of sustainable construction that aims to address issues of building's ecological, social and economic aspects in the context of its community (Kibert, 2016). Green building can be defined differently depending on the construction perspective. However, its general goal is to achieve energy and resource efficiency, realizing long-term economic, environmental and social health (Sahamir and Zakaria, 2013; Yoon and Lee, 2003). Basically it involves the application of sustainability principles to building design (Kibert, 2016). As such, being recognized as one of the fundamentals for achieving sustainability (Gundes, 2016), LCC application in Green projects is somewhat anticipated in the industry. Moreover, LCC has been adopted in an environmental and social context due to the rising concerns on sustainability and its three pillars (Zhang et al, 2021). The growing concentration in research has been apparent in this past decade, varing in its area of interest (Goh and Sun, 2016), which is an encouraging scenario. Among the studies include evaluation of different environmental friendly technological options using whole-life cycle costing (Pellegrini-Masini et al, 2010), combining the use of LCC with other methods to analyse and investigate the implications of critical input variables on LCC for making risk-informed investment decisions (Mah et al, 2018; Miah et al, 2017; Heijungs et al, 2013; Wong et al, 2010), and the attempt of comprehending whether internalisation of LCC in government tenders can be encouraged by embracing Green Procurement (De Giacomo et al, 2019), a procuring process that seek to source goods, services or work with a reduced environmental impact (European Commission, 2016). Even in Malaysia, LCC has been hailed as a vital tool to support the implementation of its own version of green procurement, and should be considered as one of the awarding criteria for decision making (KeTTHA, 2018). Another local research aimed to develop an integrated web-based automated analog computerised programming which attempts to fill the gap of local green building rating assessment tool (myCrest) and LCC. All these studies somewhat confirms the importance of LCC in green construction developments and should be further stimulated.

2.1 Challenges of LCC in Construction Industry

Previous studies have testified the significant role LCC plays either in its application in conventional building or even in green construction projects along with the many benefits that can be attained from it (Bruce-Hyrkas et al, 2018; Miah et al, 2017; Ashworth, 2010; Ellingham and Fawcett, 2006; Flanagan and Jewell, 2005; Langdon and Everest; 2004). Yet, its implementation in reality has been linked with some challenges (Patil et al, 2021). Among the challenges include difficulties in obtaining cost variables (Dwaikat and Ali, 2018), restrictions on the sort of environmental and cost impacts that can be considered due to limited knowledge during the early design stage (Zuo et al, 2017) and contradictions between practices of design, cost calculations and data management (Saridaki and Haugbølle, 2019). Availability and reliability of data such as lifespan, future costs of operation, maintenance, previous consumptions, fixed costs, and

investments, is also one of the main challenges for the mainstreaming of LCC (Khiyon & Mohamed, 2018; Hochschorner and Noring, 2011). Table 1 provides a list of challenges in implementing LCC as reported by past researchers. The challenges identified were compiled, analysed and then categorized into four (4) main challenges which are Project-related, Data-related, LCC-related and Professionals-related factors. Basically the challenges were grouped based on the nature of the challenges whether they are related or due to the project factors, data factors, LCC factors or the Professionals.

Table 1 Challenges in implementing LCC in construction industry

LCC Challenges	Authors
Project-related factor	
Insufficient project or context specific data	Zuo et al, 2017
Insufficient time to carry out LCC during the early design and procurement stage	Lim et al, 2018
Data-related factor	
Difficulties in obtaining quality cost data or variables	Hochschorner & Noring, 2011; Oduyemi et al, 2014; Khiyon & Mohamed, 2018
Difficulties in obtaining building LCA background data	Hochschorner & Noring, 2011
Difficult to determine, examine and respond to the changing cost throughout project's life span	Munro, 2008
Difficult to determine the appropriate life span of a project	Hochschorner & Noring, 2011
Difficult to determine the appropriate life span of components	Hochschorner & Noring, 2011
Difficult to determine the appropriate discount rate	Hochschorner & Noring, 2011
Difficult to define the comparable baseline	Hochschorner & Noring, 2011
LCC-related factor	
Difficulties in understanding LCC's methodological problems and limitations	Cole & Sterner, 2000
Difficulties in carrying out LCC calculations due to absent of proper LCC guidelines or framework	Wan Hassan et al, 2014
Professionals-related factor	
Difficulties in getting support and commitment among professionals	Lim et al, 2018
Difficulties in carrying out LCC exercise manually due to lack of resources (i.e. LCC software)	De Giacomo, 2018; Kambanou, 2020

However, there has been no specific research documenting the challenges faced by the Malaysian construction industry in implementing LCC in Green construction projects. This information will provide understanding that is significant in order to formulate strategies to ensure the uptake of LCC in the construction industry, specifically in green projects. Therefore, the variables presented in Table 1 will be used as basis to identify the main challenges in implementing LCC in Malaysia's green construction projects.

3. Methodology

In order to achieve the research objectives, a systematic literature review on the challenges of LCC was carried out first. The aim of the review is to identify the possible challenges encountered in carrying out LCC in green building construction project. The examination and analysis of past works on LCC also provides a better understanding on the process of carrying out LCC in the construction industry. As a result of the literature review, a total of sixteen (16) challenges were identified (refer to Table 1). This finding is then used to develop a set of questionnaire for the purpose of identifying the main challenges in implementing LCC in Malaysia's green construction projects. For the purpose of this survey, the challenges identified from the literature were grouped into four (4) main challenges based on the nature of the challenges whether they are related or due to the project-related factors, data-related factors, LCC-related factors or Professionals-related factors. The purpose of grouping these challenges is so that it would be easier for the respondentsto relate and understand the possible challenges sice it is presented in a more organized format.

The developed questionnaire consisted of three (3) sections. The first section asked about the details of the respondents. The second section carried questions regarding the profile of green construction projects undertaken by the respondents for those who have involved in green construction projects. The third section asked the

respondents about their opinion or experience on the challenges faced in carrying out LCC in green construction projects. The fourth section requires respondents to give comments on the possible ways to overcome those challenges. The questionnaire was first distributed via traditional mail which has been proven a successful method and is representative of the population (Szolnoki & Hoffmann, 2014). However, due to the current COVID-19 pandemic, response were very low. Therefore, toincrease the response rate, the questionnaire was then reproduced using google form and distributed via e-mail and other online platforms, which are known for its speedier response and lower cost (Nayak and Narayan, 2019). Moreover, survey feedback and reminders were sent to facilitate response and ensure higher response rate.

From a total of two-hundred (200) respondents namely architects, quantity surveyors, engineers and other professionals that typically would be involved in LCC preparation, a total of fifty (50) completed and usable questionnaires were collected. As shown in Table 2, the highest response rate is from quantity surveyor with 46%, followed by response from others comprising of project managers, green consultants and certifiers with 30%. While both response rate from architects and engineers were only 12% each. The overall response rate is 25% which is acceptable.

Table 2 - Respondents rate

Types of respondents	Number of questionnaires		Response rate (%)
	Distributed	Returned	
Architect	50	6	12
Quantity Surveyor	50	23	46
Engineer	50	6	12
Others	50	15	30
Total	200	50	25

4. Results

As mentioned earlier, a total of sixteen (16) challenges were identified. Respondents were required to rate the critcalness of each challenge based on a 5-point likert scale. The challenges are then ranked according to their relative criticalness, which are based on the mean score. Although the challenges have been classified into four (4) group challenges as mentioned earlier, the results tabulated in Table 3 shows the mean values and ranking based on the overall total of challenges identified. The analysis were done using IBM SPSS Statistic 26.

Table 3 - Overall ranking on LCC challenges

LCC Challenges	*Mean*	*Rank*
Insufficient project or context specific data	*3.30*	*1*
Difficulties in carrying out LCC calculations due to absent of proper LCC guidelines or framework	*3.20*	*2*
Difficulties in carrying out LCC exercise manually due to lack of resources	*3.18*	*3*
Insufficient time to carry out LCC during the early design and procurement stage	*3.16*	*4*
Difficulties in obtaining quality cost data or variables	*3.12*	*5*
Difficulties in obtaining building LCA background data	*3.10*	*6*
Difficult to determine, examine and respond to the changing cost throughout project's life span	*3.08*	*7*
Difficult to obtain previous data for economic comparison	*3.08*	*7*
Difficulties in getting support and commitment among professionals	*3.02*	*8*
Difficult to define the comparable baseline	*2.98*	*9*
Difficult to select the best possible option due to complex interrelations between different types of costs and elements	*2.94*	*10*
Difficult to determine the appropriate life span of components	*2.90*	*11*
Difficult to interpret results from LCC analysis	*2.80*	*12*
Difficult to determine the appropriate life span of a project	*2.78*	*13*
Difficulties in understanding LCC's methodological problems and limitations	*2.78*	*13*
Difficult to determine the appropriate discount rate	*2.76*	*14*

5. Discussions

For the purpose of discussion, Table 4 to 7 shows the relative ranking of the challenges inside each group factor. These rankings inside each of the mentioned tables were achieved based on the overall rankings tabulated earlier in Table3.

5.1 Analysis on LCC Challenges

Challenges in LCC implementation were categorized into four (4) group challenges. Table 4 shows the LCC challenges related to project factor, where 'Insufficient project or context specific data' is ranked first with a mean score of 3.30, followed by 'Insufficient time to carry out LCC during the early design and procurement stage' with a mean score of 3.16. In the overall ranking (Table 3), both challenges were ranked at first and fourth place respectively. This indicate that challenges under this category are the main challenges faced in implementing LCC in green construction projects, however both are only at critical level.

Table 4 - LCC challenges due to project-related factor

LCC Challenges – Project-related Factor	*Rank*
Insufficient project or context specific data	*1*
Insufficient time to carry out LCC during the early design and procurement stage	*2*

Table 5 presents the LCC challenges due to data factor. Under this category, 'Difficulties in obtaining quality cost data or variables' is ranked at number one with a mean score of 3.12, while ranked at second and third place is 'Difficulties in obtaining building LCA background data' (mean score of 3.10) and 'Difficult to determine, examine and respond to the changing cost throughout project's life span' (mean score of 3.08). All three challenges were rated 'critical' and falls within top ten position of the overall ranking (Table 3). The other challenges under this category were in overall rated as 'less critical'.

Table 5 - LCC challenges due to data-related factor

LCC Challenges – Data-related Factor	*Rank*
Difficulties in obtaining quality cost data or variables	*1*
Difficulties in obtaining building LCA background data	*2*
Difficult to determine, examine and respond to the changing cost throughout project's life span	*3*
Difficult to define the comparable baseline	*4*
Difficult to determine the appropriate life span of components	*5*
Difficult to determine the appropriate life span of a project	*6*
Difficult to determine the appropriate discount rate	*7*

Shown in Table 6 is the LCC challenges relevant to LCC factor, where 'Difficulties in carrying out LCC calculations due to absent of proper LCC guidelines or framework' is ranked at first place. In the overall ranking tabulated in Table 3, this challenge is at the second highest position ranked as 'critical' with a mean score of 3.20. While 'Difficulties in understanding LCC's methodological problems and limitations' is ranked at second place here, but in the overall ranking it is ranked at the second bottom position with a mean score of 2.78, rated as 'less critical'.

Table 6 - LCC challenges due to LCC-related factor

LCC Challenges – LCC-related Factor	*Rank*
Difficulties in carrying out LCC calculations due to absent of proper LCC guidelines or framework	*1*
Difficulties in understanding LCC's methodological problems and limitations	*2*

The final category of LCC challenges is those relevant to professionals factor. Table 7 indicates the top rank position as 'Difficulties in carrying out LCC exercise manually due to lack of resources'. This challenge ranked at third highest position in the overall ranking (Table 3), having a mean score of 3.18. The second highest rank under this category goes to 'Difficult to obtain previous data for economic comparison', while third position goes to 'Difficulties in getting support and commitment among professionals'. Both challenges has a mean score at critical level, of 3.08 and 3.02 respectively.The remaining two (2) challenges under this category are ranked as 'less critical' in the overall ranking table.

Table 7 - LCC challenges due to professionals-related factor

LCC Challenges – Professionals-related Factor	*Rank*

Difficulties in carrying out LCC exercise manually due to lack of resources	*1*
Difficult to obtain previous data for economic comparison	*2*
Difficulties in getting support and commitment among professionals	*3*
Difficult to select the best possible option due to complex interrelations between different types of costs and elements	*4*
Difficult to interpret results from LCC analysis	*5*

The findings revealed that, based on the mean score, all the LCC challenges were either rated as 'critical' or 'less critical', with slightly more than half of the challenges were indicated being at critical level. 'Insufficient project or context specific data' is ranked as the most critical challenge. This finding makes sense because as highlighted by Bogenstatter (2000), the application of LCC in early stages of design process would allow relevant construction and operating cost to influence critical decisions. As such, to carry out LCC at a very early stage would be challenging because at this stage, normally the project information is still minimal and the context is still very much vague. Which makes it common for the project team to experience insufficient project and context data to perform LCC exercise, that would allow decision-makers to fully comprehend the short-to-long term total costs and benefits of the project (Miah et al, 2017). This is also in lined with Zuo et al (2017) claim that due to limited knowledge during the early design stage, to obtain the sort of environmental and cost impact data would be restricted if not challenging.

The second highest ranked challenges is 'Difficulties in carrying out LCC calculations due to absent of proper LCCguidelines or framework'. This finding is surprising because many guidelines on LCC have been published around the world such as Australia's LCC Guidelines for Sport and Recreation Facilities, Ireland's SCS Guide to LCC, US's LCCManual for the Federal Energy Management Program, UK's RICS professional guidance on LCC and many other documents relevant to LCC Analysis. Most current one was published in 2019 by International Construction Measurement Standards (ICMS) under the ICMS Coalition which is basically a second edition to the first edition published in July 2017 to include LCC. In Malaysia, the Public Works Department (PWD) has also published the LCC Guidelines back in 2012 (JKR, 2012). However, there is no evidence that suggests that the LCC guideline helps users toeffectively carry out LCC exercise n real life project.Perhaps a much detail and clearer LCC guideline, or even a dedicated framework on LCC process for Green construction projects should be established to overcome this challenge.

Nonetheless, this does not mean that the government is not promoting LCC as a supporting decision tool for the evaluation of matters relevant to sustainable and green development. Many initiatives have been taken by governments around the world in the effort of encouraging the application of LCC in the industry (Chiurugwi et al, 2010). Nonetheless, the government should play a more active role in addressing these challenges. As revealed in a study done in the UK construction industry by Oduyemi et al (2014), one of the key factors that prevented wider application of LCC was the absence of standardized guideline, which echos the finding of this study. A couple of years later, UK's RICS professional guidance on LCC were published (RICS, 2016) perhaps in response to this finding. Same should be taken up by the relevant government bodies and institution in Malaysia perhaps to come up with a much detail and clearer LCC guideline,or even a dedicated framework on LCC process for Green construction projects, as suggested earlier. Furthermore, the government should be planning and executing more initiatives and incentives to encourage the implementation of LCC in green construction projects.

6. Conclusion

As a conclusion, it could be summarized that the application of LCC in practice is still limited, especially in green projects, eventhough research trends are increasing in this area. Clients are still wedged to the traditional approach of project development, looking towards short term initial cost, rather than the best long-term value. Besides, there is still much work to be done in justifying the need for a conscious shift of focus towards implementing LCC in green construction projects. In the mean time, effort must be taken to address or resolve the challenges faced by the project team when preparing LCC, especially the main challenges. Perhaps formulating a framework or guideline specifically designed to address these challenges would help ease the LCC preparation. The government should also enhance their effort to promote LCC in green developments among the industry players. The findings of this study serve as a valid point of reference for industry participants concerned with green developments to improve the LCC process and its adoption in Malaysia which will ultimately contribute positively towards achieving the world's green construction.

Acknowledgement

This research is funded by Ministry of Higher Education Malaysia under FRGS Grant Scheme - FRGS/1/2019/SSI11/UITM/03/1. The authors would like to thank the Ministry and Universiti Teknologi MARA for thesupport on this research.

References

Ahmad Jasmi, S. Z., Ayob, M. F., Abdul Rashid, K., and Mohd Rahim, F. A. (2018). A Review on the State of Cost Data Inputs of Life Cycle Cost (LCC) for Rigid Pavement Maintenance and Rehabilitation in Malaysia. Journal of Design and Built Environment, Special Issue 1 2018

Ashworth, A. (2010). Cost Studies of Buildings fifth edition. USA: Pearson Education Limited

Atkinson, D. (1996). Life cycle costing analysis and its application in the design of South Australian buildings Master of Applied Science thesis. Adelaide: University of South Australia

Bogenstatter, U. (2000). Prediction and optimization of life-cycle costs in early design Building Research & Information 28(5/6) p 376-86

Boussabaine, H. and Kirkham, R. J. (2004). Whole life-cycle costing: Risk and risk responses. Oxford: Blackwell.

Bruce-Hyrkäs, T., Pasanen, P., and Castro, R. (2018). Overview of Whole Building Life-Cycle Assessment for Green Building Certification and Ecodesign through Industry Surveys and Interviews 25th CIRP Life Cycle Engineering (LCE) Conference, 30 April - 2 May 2018, Copenhagen, Denmark, Procedia CIRP 69 p 178-83.

Chiurugwi, T., Udeaja, C., Hogg, K. and Nel, W. (2010). Exploration of drivers and barriers to life cycle costing (LCC) in construction projects: professional quantity surveyors' assessment Ed Tizani, W. Proceedings of the International Conference Nottingham UK p 1-9

Cole, R. J. and Sterner, E. (2000). Reconciling theory and practice of life cycle costing Building Research and Information 28(5/6) p 368-75

De Giacomo, M. R., Testa, F., Iraldo, F. and Formentini, M. (2019). Does green public procurement lead to life cycle costing (lcc) adoption? Journal of Purchasing and Supply Management p 1478

Dwaikat, L. N. and Ali, K. N. (2018). Green buildings life cycle cost analysis and life cycle budget development: Practical applications. Journal of Building Engineering 18(2018), 301-311

Ellingham, I. and Fawcett, W. (2006). New Generation Whole-Life Costing: Property and Construction Decision Making Under Uncertainty. Taylor & Francis, UK

Eriksson, O., Bisaillon, M., Haraldsson, M., and Sundberg, J. (2016). Enhancement of biogas production from food waste and sewage sludge - environmental and economic life cycle performance Journal of Environment Management 175 p 33-9

European Commission (2016). Life-cycle costing Available at http://ec.europa.eu/environment/gpp/lcc.htm (last accessed: 3 January 2019)

Flanagan, R. and Jewell, C. (2005). Whole Life Appraisal for Construction. Blackwell Publishing Ltd., Garsington Road, Oxford

Goh, B.H. and Sun, Y. (2016). The development of lifecycle costing for buildings. Building Research & Information, Volume 44(3), 319-344

Gundes, S. (2016). The Use of Life Cycle Techniques in the Assessment of Sustainability Procedia – Social and Behavioural Science 216 p 916-22

Heijungs, R., Settanni, E., and Guinée, J. (2013). Toward a computational structure for life cycle sustainability analysis: unifying LCA and LCC International Journal on Life Cycle Assessment 2013 18(9) p 1722–33.
Higham, A., Fortune, C. and James, H. (2015). Life cycle costing: evaluating its use in UK practice Structural Survey 33(1) p 73-87

Hochschorner, E. and Noring, M. (2011). Practitioners' use of life cycle costing with environmental costs - a Swedish study The International Journal of Life Cycle Assessment 16 p 897
Hoseini, G. A, Dahlan, N. D., Berardi, U., GhaffarianHoseini, A., Makaremi, N., and GhaffarianHoseini, M. (2013). Sustainable energy performances of green buildings: a review of current theories, implementations and challenges. Renewable and Sustainable Energy Reviews 2013;25:1–17

Hwang, B. G. (2018). Performance and Improvement of Green Construction Projects: Management Strategies and Innovations. Butterworth-Heinemann, Oxford, UK

Jabatan Kerja Raya Malaysia (2012). Garis Panduan Kos Kitaran Hayat (LCC)

Kambanou, M. L. (2020). Life Cycle Costing: Understanding How It Is Practised and Its Relationship to Life Cycle Management - A Case Study. Sustainability 2020, 12, 3252, 1-19

KeTTHA (2018). Garis panduan perolehan hijau kerajaan 2.0. Putrajaya: Ministry of Energy, Green Technology and Water, Malaysia

Khiyon, N. A. and Mohamed, S. F. (2018). Barriers and Drivers of Whole Life Cycle Costing of Sustainable Facility Management for PPP/PFI Projects in Malaysia, Chemical Engineering Transaction, 63, 721-26

Kibert, C. J. (2016). Sustainable Construction: Green Building Design and Delivery (4th edition). John Wiley & Sons, Hoboken, New Jersey

Kibwami, N., and Tutesigensi, A. (2016). Enhancing sustainable construction in the building sector in Uganda. Habitat International, 57, 64-73

Kishk, M., Al-Hajj, A., Pollock, R., Aouad, G., Bakis, N. and Sun, M. (2003) Whole life costing in construction: A state of the art review. The RICS Foundation Research Paper Series, 4(18), 1-39

Langdon, D. and Everest (2004). Getting Value for Money from construction projects through design. Retrieved December 17, 2018 from https://webarchive.nationalarchives.gov.uk/20110118174844/http://www.cabe.org.uk/files/getting-value-for-money-from-construction-projects-through-design.pdf

Lim, B. T., Zhang, W., and Oo, B. L. (2018). Sustainable procurement in australia: quantity surveyors' perception on life cycle costing International Journal of Integrated Engineering 10 p 1-6

Mah, C. M., Fujiwara, T., and Ho, C. S. (2018). Life cycle assessment and life cycle costing toward eco-efficiency concrete waste management in Malaysia Journal of Cleaner Production 172 p 3415-27

Maisham, M., Adnan, H., Ismail, N. A. A., and Mahat, N. A. A. (2019). IOP Conference Series: Earth and Environmental Science, 385 (2019) 012066

Mateus, R., Neiva, S., Bragança, L., Mendonça, P., and Macieira, M., (2013). Sustainability assessment of an innovative lightweight building technology for partition walls - comparison with conventional technologies Building Environment 67 p 147-59

MGTC (2019). Malaysian green technology corporation. Accessed at https://www.greentechmalaysia.my, last retrieved: 12 January 2019

Miah, J. H., Koh, S. C. L. and Stone, D. (2017). A hybridised framework combining integrated methods for environmental Life Cycle Assessment and Life Cycle Costing Journal of Cleaner Production 168 p 846-66

Mohamed Bohari, A. A., Skitmore, M., Xia, B., Teo, M, Zhang, X., and Adham, K. N. (2015), The path towards greening the Malaysian construction industry. Renewable and Sustainable Energy Review, 52(2015), 1742-1748

Munarim, U., and Ghisi, E. (2016). Environmental feasibility of heritage buildings rehabilitation. Renewable and Sustainable Energy Reviews 2016;58:235–49

Munro, Bob. (2008). Determining costs of ownership the real costs of an asset. Ontario: Federated Press

Narak, M. S. D. P. and Narayan, K. A. (2019). Strengths and Weakness of Online Surveys. IOSR Journal Of Humanities And Social Science (IOSR-JHSS) Volume 24, Issue 5, Ser. 5 (May. 2019) 31-38

Ng, B. J. H., Zhou, J., Giannis, A., Chang, V. W. C., and Wang, J-Y. (2014). Environmental life cycle assessment of different domestic wastewater streams: policy effectiveness in a tropical urban environment Journal of Environment Management 140 p 60-8

Oduyemi, O., Okoroh, M. and Dean, A. (2014). Barriers to life cycle costing usage. Ed Raiden, A.B. and Aboagye-Nimo 30th Annual ARCOM Conference Proceedings Portsmouth UK

Patil R.A., Shabunko V., and Ramakrishna S. (2021) Renewable Energy and Circular Economy: Application of Life Cycle Costing to Building Integrated Solar Energy Systems in Singapore. In: Liu L., Ramakrishna S. (eds) An Introduction to Circular Economy. Springer, Singapore. 201-18

Pellegrini-Masini, G., Bowles, G., Peacock, A. D., Ahadzi, M., and Banfill, P. (2010). Whole life costing of domestic energy demand reduction technologies: Householder perspectives Construction Management and Economics 28(3) p 217-29

RICS (2016). Life Cycle Costing- RICS professional guidance, UK. 1st ed. London: the Royal Institution of Chartered Surveyors

Saridaki, M. and Haugbølle, K. (2019). Identifying Contradictions of Integrating Life-Cycle Costing in Design Practices. 10th Nordic Conference on Construction Economics and Organization, 33-39

Sesana, M. M., and Salvalai, G. (2013). Overview on life cycle methodologies and economic feasibility for nZEBs Building and Environment 67 p 211-16

Sharma, A., Saxena, A., Sethi, M., and Shree, V. (2011). Life cycle assessment of buildings: a review. Renewable and Sustainable Energy Reviews 2011;15(1):871–5

Shin, Y. and Cho, K., (2015). BIM application to select appropriate design alternative with consideration of LCA and LCCA Mathematical Problems in Engineering p 1-14

Szolnoki, G., and Hoffmann, D. (2013). Online, face-to-face and telephone surveys - Comparing different sampling methods in wine consumer research. Wine Economics and Policy. https://doi.org/10.1016/j.wep.2013.10.001

Volkov, A., Vitaliy, C., and Dmitriy, K. (2014). Life cycle of a building Advanced Materials Research 1065-1069 p 2577-80

Wan Hassan, W. N. H., Zakaria, N., and Ismail, M. A. (2014). The challenges of life cycle cost application of intelligent building in Malaysia construction industry. Journal of Design + Built, Vol.7 (2014) ISSN: 1985-6881

Wang, N., Wei, K., and Sun, H. (2014). Whole life project management approach to sustainability. Journal of Management in Engineering, 30(2), 246–255

Wong, I. L., Perera, S., and Eames, P. C. (2010). Goal directed life cycle costing as a method to evaluate the economic feasibility of office buildings with conventional and TI facades Construction Management and Economics 28(7) p 715-35

Zhang, C., Hu, M., Laclau, B., Garnesson, T., Yang, X., Li, C., and Tukker, A. (2021). Environmental life cycle costing at the early stage for supporting cost optimization of precast concrete panel for energy renovation of existing buildings. Journal of Building Engineering, 35 (2021), 102002

Zuo, J., Pullen, S., Rameezdeen, R., Bennets, H., Wang, Y., Mao, G., Zhou, Z., Du, H., and Duan, H. (2017). Green building evaluation from a life-cycle perspective in Australia: A critical review. Renewable and Sustainable Energy Reviews 70 (2017), 358–368