

## Important Activities in Activity-based Life Cycle Cost in Building Facilities Maintenance: A Case Study

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### Abstract

Public universities' budget constraint faces various challenges in maintaining their building facilities. A cost management solution in based on life-cycle cost through activity-based could provide the systematic approach in organizing, monitoring and analyzing process of facilities' maintenance costs. The aim of this paper is to determine the important facilities' maintenance activities that should be included in an activity-based life-cycle cost process of public university building maintenance. Descriptive analysis is conducted in determining the important and non-important facilities' maintenance activities. By prioritizing activities through value added and non-value added maintenance activities, cost can be managed and controlled effectively.

*Keywords:* Maintenance facilities activities; activity-based life cycle cost

### Abstrak

Kekangan bajet antara universiti awam menghadapi pelbagai cabaran dalam mengekalkan tahap penyenggaraan fasiliti bangunan mereka. Pengurusan kos berdasarkan kos kitar hayat yang berasaskan activity dapat menyediakan pendekatan yang sistematik dalam penganjuran, pemantauan dan proses analisis kos penyenggaraan fasiliti berasaskan aktiviti. Tujuan utama kertas kerja ini adalah untuk mengenalpasti aktiviti-aktiviti penyenggaraan fasiliti yang perlu dimasukkan dalam proses kos kitaran hayat berdasarkan aktiviti untuk penyenggaraan bangunan universiti. Pendekatan kuantitatif dengan menggunakan analisis deskriptif dijalankan dalam menentukan aktiviti penyenggaraan fasiliti yang penting dan yang kurang penting. Dengan cara member keutamaan kepada aktiviti-aktiviti ini melalui aktiviti yang ada nilai-tambah dan aktiviti-aktiviti penyenggaraan yang tiada nilai-tambah, kos dapat dikawal dan diuruskan dengan baik.

*Kata kunci:* Aktiviti penyenggaraan fasiliti; kos kitaran hayat berdasarkan aktiviti

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### 1.0 INTRODUCTION

Globally, asset management industry encounters difficulties in recent years, impact from the credit crisis of 2008-2009. Simultaneously, this situation has created challenges to be faced in similar closely related fields such as facilities management. Costs of maintenance plays the critical role in the cost management of organization, especially in public sector as the budget allocation or funding is limited. The main focus of this paper is on the operational aspect, which involves major cost involvement throughout the productivity life period of a building. In the past, companies and organizations were mainly bearing on the amount of their products or services were being able to expose into the

market. At circumstances, only a few practitioners use the existing resources in a cost-effective way. This situation was merely targeting on fulfilling the requirement of demand but lack in term of using resources efficiently where it can reduce the cost in using particular objectives and expands the accomplishment of particular activities in term of budget and resource constraint.

Facilities management is based on business activity and responsive to changes in clients' needs also according to time and cost effective manner<sup>1</sup>. For many organizations, the effectiveness of their cost delivery is one of the important considerations and this profession of facilities management continuously evolves to reflect this. With facilities budgets tighter than ever in most organizations, facilities management field faces growing

pressure to maximize its investments. Initial cost remains a practical consideration, but the amount of money spent over the entire expected life of an asset is also an important part of the long-term exposure<sup>2</sup>. The key aspect of facilities management is to ensure longevity of asset lifespan in providing a better return on investment through reduced life cycle costs (LCC)<sup>3</sup>. In this matter, the main aspect to be focused in facilities management is the maintenance because building maintenance is a major activity in sustaining a building and to keep it as a valuable asset. The only way to achieve this is by operating and maintaining the facilities properly. Building facilities operation and maintenance that comprehends all the broad spectrum of services required to assure the built environment will perform the functions for which a facility was assigned and constructed. Without a proper maintenance, a facility cannot operate at its highest productivity level in achieving its function and enhancing its structural integrity and appearance<sup>4</sup>.

The basis for maintenance optimization is to find the rankings of all maintenance tasks based on their cost-effectiveness in an educational institution. Consideration on cost-effectiveness of maintenance task is a general overview where it relates the service provided in identifying the users' experience towards the service; and the costs involved in carrying out the maintenance task. Both may provide a picture on how costs have been spent effectively in order to obtain the service's effectiveness<sup>5</sup>. In the view of higher education institution, the users of the building maintenance services are the students, educators and also the office (administration) staffs. In order for a higher education institution to achieve its core business needs, maintenance activity plays a main role where it has to be affirmed with the education output at a most effective level. In fact, the majority of users of higher educational institution are the students and then followed by the number of academic and administrative staffs. In other mean, the cost-effectiveness of maintenance can be best represented through facilities conditions in an academic environment, especially in the academic built environment that contributes to the achievement of students in their education, the outcome of a teaching process for the educators and also comfortable working environment for the administrators. The maintenance service that considered in this study only covers the institutional buildings.

## ■2.0 PUBLIC UNIVERSITY AS AN ASSET TO THE GOVERNMENT

Universities represent a country's image internationally which should be accommodated with updated facilities and good maintenance practices. Public assets in Malaysia face critical problems due to lack of better maintenance that caused the government to spend higher cost every year. In the process of transforming Malaysia into a knowledge-based economy, well-educated skilled workers considered as the main source of national prosperity and wealth, therefore allocation for the higher education institutions covers huge percentage form the total allocation under Malaysian Plan<sup>6,7,8</sup>. In realizing this transformation plan, each top tier of public universities must fully understand their institutions vision and mission and meet their objectives in achieving the core business needs. At an operation level, the public universities are responsible to recognize and identify the importance of core business and its support functions and the critical required. Besides developing activity such as commercialization of R&D and fundraising, cutting down avoidable

expenditures through a good management can also be a supportive function in contributing monetary vice.

Essentially, apart from staffs and students, buildings are the most significant asset of the university organization and public universities in Malaysia dependent the strength of budget derivation they can make to governments for funds in order to keep those buildings under his authorization in a good condition<sup>9</sup>. Utilizing the government fund in a total effective way through a well-planned maintenance management will results overall goodness not only in the process of minimizing expenditure but also time and to produce a better environment of facilities management, after all, what is the point of generating more and more income but the expenditure retains the same or even increasing. Naturally, the universities' authorities are keen on provide their built facilities in the most cost-effective manner<sup>10</sup> but often maintenance of building is sometimes the first area to suffer when a university budget are reduced and it is obviously a not cost-effective option<sup>9</sup>.

In that situation, some of the critical elements that contribute to the effectiveness in building facilities maintenance might be skipped. Consequently, in educational building where facilities are very much related to the users' concern, must consider the most influenced type of facilities services in the determination of maintenance budgeting to result more effective outputs. Cost-effective decisions in maintenance necessarily need access to information and data from all areas that may affect maintenance. For instance, life cycle cost analysis planned to be implemented for university building maintenance. To achieve that objective, certain criteria and procedures for data selection and also collection are equally necessary to ensure quality because data alone will not produce cost-effective decisions<sup>11,12,13</sup>. Thus, information and data availability and reliability play an important role in producing cost-effective decision.

Institutional buildings and its facilities are very much contributes to educational productivity and achievements. Therefore, identifying the relationship, contribution and impacts of educational building facilities are important for the management purpose, where cost reduction is needed and building users (e.g. staffs and students) productivity is achieved. This study attempted in determining the elements of facilities maintenance activities that have been critical for management to focus on the costs and at the same time support the core function of institutional buildings.

## ■3.0 COST EFFECTIVENESS IN ACTIVITY-BASED LIFE CYCLE COST

In the process of applying cost-effectiveness in maintenance cost of building facilities in public university, activities or elements play an important role. Prioritizing the most important elements and/or activities in conducting the maintenance cost analysis could produce effective cost management procedure. Activity-based cost (ABC) approach is known as an effective way of undertaking maintenance cost analysis, and by considering cost-effective way in choosing the most relevant and critical elements and/or activities to the type of facilities use and the facilities users. The unnecessary and inappropriate elements and/or activities could be avoided, thus can contribute to cost reduction. User's comfortable level and their priority on the facilities services could suggest the important elements and/or activities list to be included in carrying out a cost-effective maintenance analysis or even a

cost-effective cost management tool in order to fulfill the core business of public university through the buildings.

ABC can be considered as a method of costing activities that are necessary and important for the production of the products or services, for example activities being undertaken<sup>14</sup>. ABC interprets as ways to see operating costs and provides methods to dissect the underlying activities that cause costs to exist<sup>15</sup>. This allows any organization to track the cost associated with activities performed for produced products or in delivering services. Activity variables are listed in Table 1, based on the critical review from available

literature in the building maintenance industry<sup>16,17,18,19</sup> particularly in institutional organization and also information on maintenance activities that currently in practice from universities involved in this research scope. Appropriate facilities maintenance level (referring to facility level, which is the fourth area that involves costs in activity-based costing) activities cost elements are identified which considered in developing activity-based life cycle cost in Table 2. These activities are seen to be significant and important to be separated in regarding their value to the department

**Table 1** Summary of building facilities cost elements

	<b>Bramilow and Pawsey (1985)</b>	<b>El-Haram et.al (2002)</b>	<b>Piper (2004)</b>	<b>Booty (2006)</b>
<b>Facilities maintenance</b>				
Preliminaries	√	√	√	
Substructure	√			
Columns	√			
Floors	√	√	√	
Staircases	√	√		
Roof	√	√	√	
External walls	√	√	√	
Windows	√		√	
External doors	√	√	√	
Partitions	√	√		
Internal walls	√	√	√	
Internal screens and borrowed lights	√			
Internal doors	√			
Wall finishes (decorations)	√	√		√
Other floor finishes	√	√		
Ceilings			√	
Ceiling finishes	√	√		
Painting, external	√			
Painting, internal	√			
Fixture and fittings				√
Fittings and Finishing		√		
Laboratory fittings	√			
Other fitments	√			
Special equipment	√	√		√
Sanitary fixtures	√	√		
Windows and Cladding cleaning				√
Internal areas cleaning				√
Special cleans				√
Furniture and equipments cleaning				√
Pest control				√
Waste disposal				√
Sanitary plumbing	√			
Water supply / Sewerage	√			√
Ventilation	√		√	√
Boilers			√	
Central Chillers			√	
Cooling Towers			√	
Air cooled condenser			√	
Pumps			√	
HVAC system distribution piping			√	
Steam System piping			√	
Fan coils			√	
Air handling units			√	
Rooftop HVAC systems			√	
HVAC Duct system			√	
Heat pumps			√	
Plumbing			√	√
Fire protection	√			
Lift				√
Electric reticulation/electrical	√		√	√

	<b>Bramilow and Pawsey (1985)</b>	<b>El-Haram et.al (2002)</b>	<b>Piper (2004)</b>	<b>Booty (2006)</b>
Power Transformers			√	
Lighting	√			
Transportation system	√			
Special services	√			
Security System				√
Disposal installation		√		
Energy				√
Miscellaneous items			√	
Laundry				√
Alteration and fitting out				√

**Table 2** Resource centre

Resource Centre : Maintenance (Division)				
Element	Activity Centre (pool)	Activity	Activity Classification	
Civil	<b>Building Maintenance and repair</b>	i. Roofing	Facility	
		ii. Partitions		
		ii. Doors		
		iv. Ceilings		
		v. Staircases		
		vi. Flooring		
	<b>Grounds maintenance and repair</b>	ii. Decorations	Facility	
		ii. Fittings and finishes		
		ix. Sanitary and sewerage		
		i. Footpath		
		ii. Drainage		
Mechanical	<b>Services maintenance and repair (system services)</b>	i. Windows and Cladding	Facility	
		ii. Internal areas		
		ii. Furniture and equipments		
		iv. Special cleans		
		v. Pest control		
		vi. Waste disposal		
		i. Air-conditioning unit (centralized or split)		Facility
		ii. Air handling units		
		ii. Boilers		
		iv. Air terminals		
		v. Ductwork / Ducting		
		vi. Fans		
ii. Piping	Facility			
ii. Fire protection				
ix. Plumbing				
x. Lifts				
i. Servicing of Building Automation System (BAS)				
ii. Lighting and fixtures				
Renovation	<b>Facilities Renovation</b>	i. Alterations and Additions	Facility	
		ii. Improvements		
Others	<b>Security Utilities</b>	Security system maintenance	Facility	
		Energy	Facility	
		Water		
		<b>Internal decor</b>	Interior decoration	Facility
		<b>Equipment maintenance and repair</b>	Institutional equipment	Facility
		<b>Laundry</b>		Facility
		<b>IT / Computers</b>	PC maintenance	Facility

Thus, the aim of the study is to identify the facilities maintenance activities that are considered value added and non-value added activities to the public universities in order for them to undertake a cost management tool for building facilities maintenance.

#### ■4.0 SCOPE OF RESEARCH

This research is limited in scope to the public higher educational institutions (public university) in Malaysia and focused mainly on those public universities entitled under research university status. Public universities are under the control of government with objectives in line with Ministry of Higher Education. There are three categories of public higher educational institution in Malaysia, which are research universities, comprehensive (broad based) universities and focused (specialized) universities. To date, there are 20 public universities, where five are research universities, four comprehensive universities and 11 focused universities. Research universities have been selected to be studied-on in this research based on the funding level or stage. Malaysian government provides fund about 90% for the public universities whereas the remaining 10% is covered from students' fees. Reason for focusing on Research Universities mainly because of restrictions and new policies were introduced by the government in the funding criteria for these universities. Research universities that mentioned are Universiti Malaya, Universiti Kebangsaan Malaysia, Universiti Putra Malaysia, Universiti Sains Malaysia and Universiti Teknologi Malaysia.

#### ■5.0 METHODOLOGY

These universities are not only categorized under the same title but also among the oldest public universities in the country with the most of them having been operating for more than 30 years. Thus, the maintenance of building in those universities would have passed through several critical stages since when it had been established; simultaneously it could inform the taxonomy of building service maintenance in higher educational institution. Hence, five public universities will be included in the survey which represents about 23% of the total public universities in Malaysia.

Questionnaire survey undertaken in identifying the critical maintenance activity cost element in terms of the level of importance given by the service providers of public university in activity-based life cycle cost process. Four scaled questionnaire developed based on the extensive literature reviews and a series of discussions with those in the university building maintenance field and concern about university building management. Probability sampling is used in this research as the convenience sampling as the respondents are willing and available to be studied.

Activities that highlighted in yellow shows the most important activities that preferred by most of the institutions to be included in conducting life cycle cost in building maintenance. Activities such as roofing, ceilings, floorings, and also sanitary and sewerage are considered as important in civil facilities maintenance. In ground maintenance and repair category, drainage was considered important to be included in the life cycle cost process.

For sample size, each university owes a maintenance department or divisions consist of several maintenance units. For

this research purpose, five units of building maintenance were selected. Averagely each unit consisted of four to five officers and the selection was made as follow:

Research universities	(5)
Maintenance departments involved	(5)
Units involved (five in each department)	(5x5 = 25)
Respondents	(25x5 = 125)

However, a total number of 125 questionnaires were passed to the officers and staffs personally in all the five universities. A total of 100 usable questionnaires were responded and returned. Meanwhile, 25 additional questionnaires were returned that were not considered useable. With 100 returned and usable questionnaires out of 125, the response rate was 80%. The questionnaire consists of two parts. The first part, section A consisted of demographic information such as respondents rank of position or occupation, number of years in service, facilities under their jurisdiction and finally understanding on LCC concept. The second part, section B of the questionnaire consisted of maintenance activities detail elements. Respondents were asked to indicate their opinion on the various dimensions of maintenance activities involved in public universities' facilities maintenance as the variables being studied. Data gathered were descriptively analyzed using quantitative analysis software to determine the important or not important to be considered for life cycle cost.

#### ■6.0 RESULT DISCUSSION

The respondents comprised of civil, mechanical, electrical, renovation and other maintenance work officers who handled the activities. The respondents are also experienced in terms of maintenance and management of building facilities, including costs involved in maintenance works. Figure 1 consists of the number of respondents and the institutions and maintenance units involved in this survey. It also reveals the respondents' background in buildings maintenance of overall five (5) institutions involved in this study. The respondents are experienced in their fields from three (3) years up to 20 years. They have sufficient knowledge on life cycle cost and involvements of maintenance activities in cost related management and also analysis, hence strengthen their opinion on the important activities to be included in activity-based life cycle cost process.

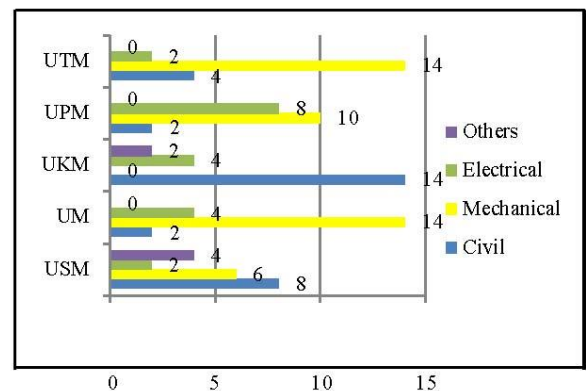


Figure 1 Respondents and field of work

Besides that, cleaning of windows/cladding/decorations, internal areas, furniture equipments, special clean and; pest control and waste disposal are also those activities mentioned as important under civil facilities of institutional buildings. While, under mechanical facilities, air-conditioning and the related to it such as air handling units, boilers, air terminals, ductwork, fans, piping, and; fire protection, plumbing and lifts are said to be important to be included in life cycle cost of institutional building maintenance. Other than that, both activities listed under electrical facilities, building automation system and; lighting and fixtures maintenance related cost are considered important in doing life cycle cost whereas, improvements is considered important in renovation maintenance work. Lastly, other maintenance activities that suggested by respondents to be included in life cycle cost process are energy, water, institutional equipment and

maintenance of computer.

## 7.0 CONCLUSION

Most of the facilities maintenance activities that preferred to be included in life cycle cost process of university building maintenance as shown in Table 3 to Table 7 are those plays an important role in the facilities functions and services provided for the building occupants. Therefore, implementation of Activity-based life cycle Cost could increase the long-term profitability by identifying improvement opportunities by examine all activities that relevant and making most appropriate selections and adaptations in maintenance activity costs for institutional buildings facilities management.

**Table 3** Civil facilities maintenance activities

Activities	Average Mean	F	Sig	Remark
Civil				
Building maintenance and repair				
<b>Roofing</b>	3.3300	3.0090	0.0220	Significant
Partitions	2.6400	14.6650	0.0000	Significant
Doors	2.8600	4.5380	0.0020	Significant
<b>Ceilings</b>	3.1600	3.2910	0.0140	Significant
Staircases	2.9100	2.5570	0.0440	Significant
<b>Flooring</b>	3.0800	0.4520	0.7710	Not significant
Fittings /Finishes	2.9500	3.9650	0.0050	Significant
<b>Sanitary/ Sewerage</b>	3.5000	2.4060	0.0550	Significant
Ground maintenance and repair				
Footpath	2.8800	4.0580	0.0040	Significant
<b>Drainage</b>	3.3740	0.2280	0.9220	Not significant
Cleaning				
<b>Windows &amp; cladding / decorations</b>	3.0600	1.2100	0.3120	Not significant
<b>Internal areas</b>	3.2600	1.4960	0.2100	Not significant
<b>Furniture &amp; equipment</b>	3.1300	3.2190	0.0160	Significant
<b>Special clean</b>	3.0200	3.9530	0.0050	Significant
<b>Pest control</b>	3.2400	5.9600	0.6670	Not significant
<b>Waste disposal</b>	3.3420	2.0150	0.0990	Not significant

**Table 4** Mechanical facilities maintenance activities

Activities	Average Mean	F	Sig	Remark
Mechanical				
Service maintenance and repair				
<b>AC/split unit</b>	3.4900	2.5700	0.0430	Significant
<b>Air handling units</b>	3.4000	2.5700	0.0800	Not significant
<b>Boilers</b>	3.3300	1.8030	0.1350	Not significant
<b>Air terminals</b>	3.3200	1.3240	0.2670	Not significant
<b>Ductwork</b>	3.2400	2.5710	0.0430	Significant
<b>Fans</b>	3.2400	0.9120	0.4600	Not significant
<b>Piping</b>	3.2200	0.5920	0.6660	Not significant
<b>Fire protection</b>	3.6100	4.1550	0.0040	Significant
<b>Plumbing</b>	3.3100	2.0130	0.0990	Not significant
<b>Lifts</b>	3.7700	2.3290	0.0620	Not significant



**Table 5** Electrical facilities maintenance activities

Activities	Average Mean	F	Sig	Remark
Electrical				
<b>BAS (Building automation system)</b>	3.8400	1.7860	0.1380	Not significant
<b>Lighting &amp; fixtures</b>	3.5600	4.1270	0.0040	Significant

**Table 6** Renovation maintenance activities

Activities	Average Mean	F	Sig	Remark
Renovation				
Alteration / Additions	2.9100	1.6480	0.1690	Not significant
<b>Improvements</b>	3.3400	1.9310	0.1120	Not significant

**Table 7** Other maintenance activities

Activities	Average Mean	F	Sig	Remark
Others				
Security system	2.9700	0.7510	0.5600	Not significant
<b>Energy</b>	3.5100	1.8070	0.1340	Not significant
<b>Water</b>	3.3500	2.0650	0.0910	Not significant
Interior decoration	2.9000	2.6390	0.0390	Significant
<b>Institutional equipment</b>	3.5400	2.0580	0.0920	Not significant
Laundry	2.8800	1.2730	0.2860	Not significant
<b>PC maintenance</b>	3.3700	4.6060	0.0020	Significant

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