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Editors

Sio-Iong Ao
International Association of Engineers, Hong Kong

Alan Hoi-Shou Chan
Department of SEEM, City University of Hong Kong, Kowloon Tong, Hong Kong

Hideki Katagiri
Department of Systems Cybernetics, Graduate School of Engineering, Hiroshima University, Higashi-Hiroshima, Hiroshima, Japan

Li Xu
College of Electrical Engineering, Zhejiang University, Hangzhou, China

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Standard for uniformity in building engineering services price forecast

G. Amuda Yusuf & S.F. Mohamed
Universiti Teknologi Malaysia, Malaysia

ABSTRACT: Establishment and implementation of a standard method of measurement for building engineering services can significantly improve the reliability of project cost estimates and cost control of the entire building project. Current practices in the formulation of building engineering services contract price, was determined and the factors that influenced the current practices established. The provisions of the current standard method of measurement in use in Malaysia were examined in relation to current building engineering services procurement and cost management. A total of 47 tender documents was reviewed in Southern Peninsular Malaysia. The research has allowed conclusion to be drawn as follows: there is no uniformity in the tender documents prepared by various consultants for the procurement of building engineering services. Standard method of measurement could be used as a basis for forecasting price of building services. Factors that influenced its non adoption include inadequate design information on building services and slow learning curve by practitioners.

1 INTRODUCTION

The Malaysian Construction Industry Masterplan (2006–2015) was developed to reinvent the Malaysian construction industry so as to become one of the best in the world. One of the strategic thrusts of the master plan is to integrate the construction industry value chain to enhance productivity and efficiency. Integrating the functions of the various parties in the construction value chain would save time and resources at the development and facility management phases of construction

BES is an important Subsector of the construction industry that requires improvement in the procurement and cost management process. This will enable the Subsector to meet up with the Construction Industry Development Board's (CIDB) plans to bring together all the players along the supply chain to collaborate in delivering cost effective solutions as stated in the Construction Industry Master Plan (CIMP 2006–2015). Meanwhile, Building Engineering Services (BES) cost could make up to 50% of the total cost of a complex building project. There has been great concern among industry stakeholders that parties involved the procurement and cost control of the important element of buildings have a uniform and structured format adopted for preparing its Bills of Quantities (BoQ). (Construction Industry Development Board, CIDB, 2009b; Sabaria, 2009) The major cause of this problem includes a reluctance to change, lack of regulating and enforcement body, very slow learning curve, attitude and clients insufficient knowledge of the benefits of adopting the standard method in preparing bills of quantities for BES services (Sabaria, 2009).

The objective of this chapter is to investigate the current functions of the parties involved in the procurement and cost management of building engineering services with the aim of examining the approaches used in the forecasting of BES contract price. It is therefore pertinent to consider some relevant questions relating to the study. How is the BES contract price determined? What are the methods adopted by parties in establishing BES contract price? What are the problems with the methods adopted? What can be done to enable parties to adopt uniform pricing methods for elements of BES? In essence, standard for uniformity in the forecasting of BES contract price refers to a generally accepted standard by practitioners that could be used as a basis for predicting the cost of BES in the context of the Malaysian construction industry.

It is essential to state that, adoption of such standard for preparing Bill of Quantities (BoQ) for BES in buildings is essential in order to achieve better value for client's money in a transforming economy. This argument is underpinned by the fact that the value and complexity of M&E services in modern buildings are becoming more complex and currently, practitioners have no common standard used as a basis for forecasting contract price of BES as used for building fabrics and finishes (Construction Industry Development Board, CIDB, 2009b). Standard method of measurement is generally adopted as the basis for forecasting contract price of building fabrics and finishes.

But the cost management of M&E services in buildings is assigned to building services engineers by way of provisional and Prime Cost sums (PC sums) which makes it extremely difficult and risky for cost consultants to manage its cost. Therefore, a window of opportunity is missed by cost consultants at the early stage of design development to effectively plan the cost of BES.

The use of SMM-based BoQ can significantly improve cost control and risk management on BES contract, as it enables fair sharing and allocation of risks between the employer the clients and subcontractors. Therefore, this chapter provides a brief description of a standard method of measurement, outline description of BES systems including its measurement evaluation of current practice in relation to the provision of the rules of measurement currently in use in Malaysia was carried out and lastly, the study suggested measures to facilitate the establishment and adoption of SMM for preparing BES BoQ in Malaysian construction industry.

2 STANDARD METHOD OF MEASUREMENT (SMM)

Standards have been described as a social-economic construct reflecting a balance of views among stakeholders and they are expected to be objective, definitive and robust (Ahleman, et al., 2009). Standard Method of Measurement (SMM) according to (RICS, 1998; RICS, 2012) is a document that provides "a uniform basis for measuring building works and the purpose is to ensure that Bills of Quantities (BoQ) fully described and accurately represent the quantity and quality of the works to be carried out". It is a document that contains a standard format for the presentation of a measured work and set of rules which are mutually known and accepted (Parker, 1996). According to (Molloy, 2007), SMM set out detailed rules for the measurement of commonly occurring works and provides guidelines as to what a tendering contractor is to allow for against each measured item. One important purpose of Standard Method of Measurement is set out in section "A" (General Rules) of Malaysian Standard Method of Measurement (SMM2) clause A.1 which states that

> *"this Standard Method of Measurement provides a uniform basis for measuring building works and embodies the essentials of good practice....."*

Clause A.2 further states that

> *"Bills of quantities shall fully describe and accurately represent the quantity and quality of the works to be carried out....."*

The rules contained in SMM have the status of a guidance note which contains recommendations that meets a high standard of professional competence. However, the Standard-Based BoQs are more than mere physical quantities of the work to be executed as the description of measured work items provides the economic and legal framework under which the work would be executed (Oforeh & Alufohai, 1998; Oforeh, 2008). In essence, the purpose of the BoQ according to (Molloy, 2007) will fail unless there is agreement as to the exact manner in which the items in the BoQ are to be measured and; the exact requirements as to what is to be included in the rate for each item. Therefore, for a successful procurement to occur, the bidding information must possess the following attributes (Oforeh & Alufohai, 1998):

- The contents of the information must convey equal meaning to all the parties involved with the project at the various stages of its implementation.
- The information must have clear and unambiguous rules with respect to the authority and responsibility of all parties involved with the project.
- The extent and quality of work envisaged should always be visible, and the various parts or sections of the information should at all points in time be consistent with each other.

The bills of quantities that is based on or prepared in line with detail rules of Standard Method of Measurement (SMM) actually contain data and information that have been effectively coded by the regulation of the said SMM and stored in the open pages of the bills, ready for retrieval by the estimators for further analysis as an integral part of the process of contract procurement (Potts, 2008; Molloy, 2007). Although establishing the rules of measurement for BES systems is not new in Malaysia as the provisions for its measurement are contained in SMM2.

The rules of SMM2 are not adopted for building services measurement because the design information available at tender stage are not sufficient for detail measurement as required by the provisions of SMM2. Moreover, quantity surveyors are not sufficiently skilled in the technology of building services and services consultants are not conversant with the rules of measurement. In addition, the current SMM2 was modeled on British SMM2, and still drafted in prose format. Therefore it does not reflect the views of industry stakeholders and local best practices, so the rules are not generally accepted. SMM2 does not lend itself to easy adaptation for computer applications and interoperable technologies like Building Information Modeling (BIM) (Amuda–Yusuf & Mohamed

2012b: Amuda-Yusuf et al. 2013). Some of the purpose of a standard method of measurement is outlined in the foreward to the first edition of civil engineering standard method of measurement published by Institution of Civil Engineers in 1976 as:

- To standardise the layout and contents of bills of quantities prepared according to the standard method of measurement
- To provide a systematic structure of BoQ items leading to a more uniform itemization and description
- To review the sub division of work items to ensure a more balance description of items
- To take account of new techniques in the construction management.

Even though literature survey revealed that the use of BoQ for interim measurements may be reducing, the BoQ is still the most widely used cost model by the parties in estimating cost in the iterative process of design development to refine the design and specification and for appointing contractors. The reliance on BoQ based upon SMM has made the Quantity Surveyors and the estimators to be used to the long established format in pricing and cost analysis. Therefore, the pricing of such BoQ are naturally carry out using data from long-established data bases.

According to (RICS, 2012), the original pupose of BoQ was to: Provide an equal basis for tendering contractors to submit tenders; convey the exact client's requirements on the projects; save the tenderers' time and cost in having to prepare BoQ individually; act as a payment document during the construction phase of a project. (Lal, 2002) explained that the uses to which BoQ are put has changed dramatically and is at variance with its original theoretical objectives as presented in Table 1.

However, literature review seems to indicate that the use of BoQ now covers cost estimating model, tendering model, planning model and contractor's site cost control model, used in valuation of variations and delay and disruption claims.

Table 1. Uses of bill of quantities.

User	Uses
Client	• Helps to define client's requirements or material specification • Allows easy comparison of tenders • Provides basis for costing alternative designs • Assist in construction supervision
Contractor	• Provide good basis for estimating and tendering • Guide in obtaining quotations for materials from subcontractors • Assist in planning and scheduling • Cost control • Provide basis for cash flow prediction • Helps in construction site management
Contractual interface	• Serves as basis for assessing interim valuation • Assist in assessing value of variations • Provide basis for remeasurement of work

3 BUILDING ENGINEERING SERVICES (BES)

Building engineering services refer to all systems that are installed in a building to provide us the comfort levels that we desired in buildings. It is comprised of mechanical and electrical (M&E) services systems that made the production and distribution of technical building services in the spaces. It includes the operations, coordination through automatic and manual controls in order to achieve the desired indoor air quality. BES are generally categorised into mechanical systems, electrical systems and building operations systems as shown in Table 2 (Tao & Janis, 2001).

Sustainable enhancements in buildings also include the installation of combined heat and power (chp), district heating and cooling, ground source heat pumps and wind turbines which are conventionally not included in the cost management of building services. BES has also expanded into building intelligence and the use of prefabricated and pre-assembled building services system.

Building intelligence comprises of improved occupant comfort and productivity, reduction of whole life costs, improvement in energy management and greater adaptability to organizational changes. The technology of intelligent started from the automatic intelligent control of some building engineering services processes and communication devices. It developed along with the computer and information technology, the evolution of electronic technology. Because of advances in technology, the level of integration of intelligent building is being developed from the subsystem level of total building integration and convergence of information systems. The issues of sustainability enhancement and intelligent buildings have really contributed to the complexity and increase in value of elements of BES systems.

In the traditional practice, the procurement and cost management of BES was simple and straight forward and sub-contractors are procured based on lump sum performance specification without

Table 2. Primary building engineering services subsystems.

Systems	Description
Mechanical	Heating, Ventilating, and Air Conditioning (HVAC)
	Site utilities: water supply, storm water, drainage, sanitary disposal, gas supply
	Plumbing: Water distribution, water treatment, sanitary facilities
	Fire protection: water supply, stand pipe, fire and smoke detection, automatic sprinklers, annunciation etc.
	Special systems (e.g. sustainability enhancement features)
Electrical	Electrical power: Normal, standby and emergency power supply and distribution,
	Lighting: internal, external, and emergency lighting
	Auxiliary: Telephone, signal, data, audio/video, sound, fire alarm, security systems etc.
	Special systems (e.g. sustainability enhancement features)
Building operation	Electrical power: normal, standby, and emergency power supply and distribution
	Processing: production, food services, etc.
	Automation: environmental controls, management etc.
	Special systems (e.g. sustainability enhancement features)

consideration for quantification of items of BES. The trend today is obviously different, the BES systems industry is fast changing with increasing complexity, value and the numbers of parties involved are also increasing. It is obvious that efficient financial control of this element of building in a structured format is essential; to enable correct and timely decisions to be made, so that clients would not be exposed to a serious financial risk.

4 MEASUREMENT OF BUILDING ENGINEERING SERVICES

Measurement is central to the financial management of construction projects and it involves the cost consultants/quantity surveyor in measuring different types of work as shown on the drawings produced by the architect or engineer. The quantities are often extracted from the drawings line with the rules of accepted SMM and the tender document prepared is referred to as BoQ. The completed BoQ is normally forwarded along with other documents for the contractor to price.

The measurement of building services can be simplified into three functional elements that apply to all types of supply installations, namely source (e.g., boilers, air handling equipment, transformers, stand-by equipment etc.); distribution (e.g., piping, ducting, cable, wiring, conduit etc.); and outlets (e.g., radiators, air grilles, lighting points, power outlets). Source and outlet elements are usually enumerated, whereas distribution elements are generally measured by length as shown in Figure 1 (Murray, 1997). Although building services measurement is not straightforward because it is not practicable to measure all items involved, nevertheless, it is important for the cost consultants to quantify as much as possible and provide details and all necessary cost significant information about BES components that could not be quantified in line with the rules of measurement.

The description is another important aspect of price forecasting. Item description requires the correct use of vocabulary and grammar along with correct construction of sentences during measurement. The description should be clear, concise, correct, and complete. A consistent use of terms and language in a structured format that contributes to a better

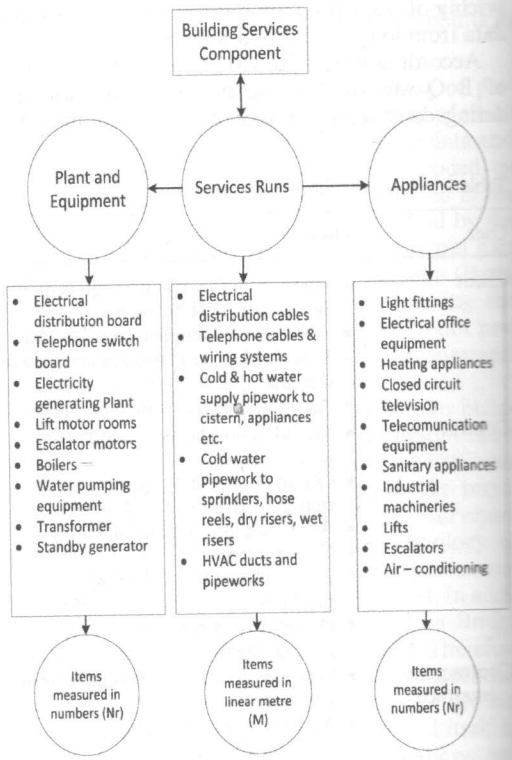

Figure 1. Building services components and units of measurement.

communication is highly required. If the description is not correctly written, then a different item would be purchased and delivered to site by the contractor. Therefore, it is important to provide sufficient information that could be understood by another surveyor or estimator. The following are the checklist that could be adopted by a measurer in building up description for each item of building services:

- Does the BES item have a specific name (e.g. cable tray, Trunking, cable, kitchen sink)?
- Does the item have a size (e.g. 150 mm, 1.5 mm, single drain)?
- What type of material is the item made of (e.g. Galvanized iron, upvc, copper)?
- What type of testing and inspection are required?
- What is the Malaysian or British standard number (MS/BS)?
- Does the item have to be fixed vertically, horizontally or at a specific angle?
- What level of workmanship should be achieved?
- Could another person (estimator, clients) understand what has been described?

Information of this kind would allow the estimator to have full knowledge of what should be included in the price of each item. As over-pricing or underpricing of any of the items could put the contractors in difficult situations during tender evaluation.

5 DETERMINATION OF BES CONTRACT PRICE IN MALAYSIA

The Malaysian Standard Method of Measurement of Building Works (SMM2) published in 2001 and it constitutes key aspects in the preparation of tender documents for new buildings in the Malaysian construction industry (ISM, 2001). However, in SMM2, the rules for measuring building services are referred to under section Q (Plumbing and Mechanical Engineering Installations) and Section R (Electrical Installations). While section Q covers rules for measuring plumbing and mechanical engineering installations, section R provides rules for measuring electrical installations. The rules for measuring Plumbing and Mechanical Engineering Installations in buildings are given under a total of 32 clauses while the rules for measuring electrical services installations are given under a total of 24 clauses. All the clauses and sub-clauses are arranged under the following headings:

- Q. 1 & R. 1–Generally (information)
- Q. 2 & R. 2–Classification of work
- Q. 3 & R. 3–Location of work,

In addition to the provisions of sections Q and R, the rules in sections A—General rules and B—Preliminaries of SMM2 are also applicable. Moreover, some of the clauses under sections Q and R provided cross references which require measurement to be done in accordance with the rules of some other sections. A typical example is in clause Q.32.1 and R.24.1 which requires trench excavation for pipes to be given in accordance with clause D.12.9 and V.2. Similarly, clause B.8 (1–2) of SMM2 required works to be carried out by a nominated sub-contractor to be given as Prime Cost sum (PC sum). It provided an item for general attendance which is deemed to include the use of main contractor's temporary roads, pavings and paths, standing scaffolding, subcontractor's site office security among others and all these shall be without charge to the sub-contractor.

However, contrary to the provisions of SMM2, virtually all the tender documents reviewed contained provisions which stated that:

> *"The sub-contractor shall be responsible for the provision, erection, maintenance and removal of all his temporary office and payment of other charges; reimburse all expenses by the contractor for the repair of roads in a proportionate amount of his contract sum to the total contract sum"*

This kind of provisions will make the items of attendance to be priced twice (first by main contractor under PC sums and secondly by nominating sub-contractors) at the expense of the employer. In addition, sub-contractors are subjected to unnecessary pressure of having to construct temporary structures that are not part of core specialist work. Contradictions of this nature could be avoided if the rules of measurement are strictly adhered to and clients will not be made to bear the risk of the likely disputes resulting from this kind of inconsistencies.

Generally, the implication of the provisions of SMM2 is that tender documents prepared on its basis must be priced in accordance with the rules of the method and requires that the estimator should have full working knowledge of the method concerned. Some of the rules in standard method may not be adequate for measuring some types of work items and it is in view of this that SMM2 provided in clause A.2.2 that

> *"Rules of measurement adopted for work not covered by these rules shall be stated and such rules shall as far a possible conform to those given in this document for similar work".*

This provision is essentially necessary in the context of Malaysian construction industry because, the construction methods and cultures from different corners of the world are significantly in use in addition to local practices and construction

procedures in Malaysia, as against the system of construction in more developed countries. Furthermore, there are some "deemed included items" which requires estimators be conversant with the rules of SMM2 because underestimation of deemed to be included items could lead to underpricing, similarly, overestimation of 'deemed to be included items' could lead to overpricing of work items.

In the study conducted by (Kumar, 2009) on the consulting engineer's perspectives on the standard method of measurement in Malaysia, he stated that: schedule of prices is often used rather than bills of quantities for M&E services works; and where BoQ is used the method of measurement are usually spelt out either in the preamble to the BoQ or in specifications and different consultant may have different bills of quantities. The lump sum contract is stated to be the most popular for procurement of M&E services in Malaysia (Stephen, 2009; Amuda–Yusuf & Mohamed, 2011; Amuda–Yusuf & Mohamed, 2012). In most cases, clients' interests are often protected with a disclaimer and similar contractual provisions such as:

> *"the successful tenderer shall provide all materials and necessary fittings and perform any work which is necessary for the proper and efficient function of the complete electrical system even though such materials, fittings or works may not be explicitly mentioned in this specification or shown on the drawings attached to this specification....."* *(Stephen, 2009).*

Although, according to (Entrusty, 2011) this type of provisions will safeguard the interest of the employer from being held accountable to the contractor for any inaccuracies in tender documents. Nevertheless, (Molloy, 2007) opined that such provisions are "short-sighted in the extreme and serve only to destroy the primary functions of BoQ". Molloy further argued that if the engineer does not know for certain what is allowed for in each rate, how can he use those rates for the valuation of variations? Similarly, if one of the "deemed included" item is omitted how can such omission be valued? It is widely accepted that a financial vacuum that is difficult to manage is created when building services tenders are invited on the basis of the lump sum and schedules because this often give rise to a wide difference between the highest and the lowest tender and it is subject to manipulation by experienced contractors.

Furthermore, where BoQ are used, the method of measurement is rarely detailed enough to provide a uniform basis for contractors to submit tenders on a uniform basis. For instance, Table 2 shows a brief comparison of SMM2 requirements for measuring cables and what is currently practiced in Malaysia.

The implication of not adopting SMM for building services would make parties to adopt different measurement, definition, coverage rules and description of items of building services leading to confusion. Difficulty in understanding the building services components to be provided by contractor leading to clients' exposure to financial risk.

The type of provision in "PB.1" above will make tender preparation more complex because it shows that the BoQ is not comprehensive enough and the contractor must re-check for any omitted items, perhaps by engaging a quantity surveyor, consequently, increasing the time and cost required by contractors to submit tenders. In addition, the

Table 2. Current practice in measuring cable and SMM2 provision.

Current practices	Standard method of measurement requirements
BoQ.1 Supply and install 70 × 4 core PVC/swa/PVC cable laid underground complete with excavation and backfilling and cable slabs from substation to the main switchboard and any other necessary specification	Cables R15.2f: 70 × 4 core PVC/swa/PVC copper conductor; laid in trenches (trench and duct measured separately) (lin. m) Builders' work R.24.1: excavate trench for cables commencing from existing ground level, width not exceeding 250 mm, average depth 250–500 mm and backfill with clean river sharp sand and remove surplus from site (lin.m). R.24.2: 450 mm long × 150 mm wide × 50 mm thick plain precast concrete mix (1:2:4) cable protection tiles overlay on armoured cable (lin.m)
BoQ.2 Supply and install 25 mm² single core PVC cable on cable tray/ladder/ Trunking in accordance with the drawings and specification	Cables R.15.2b: 25 mm² single core PVC cables drawn into Trunking Trunking and fittings R.10: 200 mm wide × 75 mm deep overall purpose made Trunking in 16 swg galvanized steel sheet, divided into 3 compartments with cable belt loops and 3 no. Screwed access cover in accordance with drawing no..... (lin.m) R.10.2: extra over stop and; bend etc. (enumerate)

descriptions of items in "BoQ.1 and BoQ.2" as shown in Table 2 are inadequate and cannot be said to have provided a uniform basis for tendering contractors to submit a quotation. Similarly, at post contract stage, cost control exercise is complicated. The overall effects of these are:

5.1 *Difficulty in tender evaluation*

Tender assessment is complicated because items in the bills of quantities are not comprehensive and the contractor is deemed to have allowed for all required items whether or not they are measured. For instance, the description in **"BoQ.1"** comprises of three measurable items that are required to be quantified in linear meters according to MYSMM2 (Cable, Excavation and cable cover). The problems that can arise in this situation are in two folds:

The first problem is that it becomes impossible to know the items the contractor actually allowed for and those items that were not allowed for during the tender assessment.

Secondly, even when contractors allowed for these items, different contractors can price for these items in different ways—the width and depth of excavation, the type of covering materials (if concrete, what mix ratio) the contractors have assumed. Under "BQ.2" however, there are various sizes, make and quality of Trunking materials—the price of tenderer quoting for coated steel Trunking will be different from the contractor quoting for galvanized Trunking. Fair judgement during evaluation under these circumstances is questionable and difficult for consultants to claim that analysis of tenders have been carried out on the same basis (Molloy, 2007).

5.2 *Problems in assessing the amount due in interim valuation*

Interim valuation becomes difficult to prepare since there was no proper breakdown of items of work at tender stage. Just as enunciated above, during progress of work, if the contractor has carried out excavations and supplied cable. The exact amount due to the contractor is disputable and the contractor may not agree because the basis for valuation was not properly defined at tender stage (Molloy, 2007).

5.3 *Difficulty in agreeing value of variation*

Establishing a basis for valuing change order during the progress of work is complicated. The conditions in the standard forms of contracts require that the variation be valued using the "rate stated in contract bill for such work". If the description and measurement unit of a particular item is omitted or not properly described, there is a possibility that contractor will claim for variation which might be high in cost. Under this type of arrangement, determining the impacts that variations can have on the contract price and time can be arduous due to the interconnected nature of the construction work and the difficulty in isolating factors M&E services to quantify them. Nevertheless, the most frequent effects of variation order have been identified as: increase in project cost; rework and demolition; delay and possible time overrun; increase in overhead expenses [18]. Sometimes when not properly administered, it can result to disputes between the contractor and the client. This could result into more cost being incurred by the client as highlighted below:

5.3.1 *Delay to overall programme*

Delay to overall programme leading to extension of time,—another problem that can arise is time taking to resolve contractual problems arising from incomplete pricing information. It should be noted that time would be required to order for materials when variation is finally agreed, the lead time and time to fix these will again impact on other works in the line. For instance, owing to the nature of M&E services finishing work cannot commence until the completion of variation work, and if already done, then, a rework will be considered on the part affected.

5.3.2 *Probable loss and/expense by the contractor*

The cost of delay loss of profit and additional overhead cost will have to be claimed by the main contractor. In addition, claims will also be made on the cumulative impact of the changes on other work and associated builder's work.

5.3.3 *Disputes on methods of measurement*

The method of measurement adopted is another problem because some of the standard forms of contract in use in Malaysia (CIDB 2000; PAM2006 and PWD 203A) require that bills of quantities for construction project be prepared using approved Standard Method of Measurement in Malaysia, therefore, if an allegation of under-measurement or inadequate information for pricing purposes arises on a contract against the employer. The court will likely take account of the contents of and exact interpretation of the Standard Method of Measurement in use at the time the tender document is prepared (RICS, 2012). It should be noted that these can have a negative effect on the progress and consequently lead to time and cost overrun.

In the building engineering services tender documents, contractors have the choice to select the brand and country of origin of most equipment required for mechanical and electrical projects. Although, it is argued by practitioners that, consultants are not allowed to name a specific

suppliers or components manufacturer, however, the problem with this is that, in the Malaysian Construction Industry, there are significant variations in material quality and costs and it is possible to find a range of materials and plant with similar design capabilities, quality attributes and manufacturing standards, but with significant variation in the efficient life cycle and market prices. It will be difficult to assess the most responsive tender price when bids are being evaluated. It is therefore reasonable to state that, forecasting cost of M&E services is would be unrealistic unless the component design, quality and market place attributes and in some cases the manufacturer can be fixed. The mechanisms traditionally employed by quantity surveyors to achieve the communication of project quality specification and uncertainty attached to a proposed project are the adoption of Standard Method of Measurement to prepare detail bills of quantities. It is therefore desirable and reasonable to suggest that, practitioners should be allowed to specify M&E service components of required make or equal and approved specifications in order to safeguard wide variants from anticipated quality and quality actually supplied and installed by contractors.

6 BASIS FOR UNIFORMITY IN BES CONTRACT PRICE FORECASTING

Providing a good basis for forecasting the contract price of BES will require establishing measurement rules similar to SMM and civil engineering standard method of measurement to be adopted by parties involved in the procurement and cost management of BES in Malaysia. Common method of defining element of building engineering services should be agreed. The rules should govern information relating to cost significant features of all components of building services such as:

- The purpose of BES components
- Part of the building where the component is located
- The method to be adopted in Installing the components
- The physical dimension of the components
- The quantity of such component required in the building
- The quality of materials the component is made of and
- The treatment of the components prior to installation
- Method of handling the component.

Therefore, if BES BoQ, is based on this type of rules of measurement then it would be fairly easy for the cost consultants to detect extremely high or extremely low rates entered by the tenderer as all the tenders can be tabulated comparatively under similar guidelines. This will also create good opportunities for the adoption of value engineering. Analyzing and comparing item rates in BQ will be of great help during the negotiation for a discount with the successful tenderer. Similarly, at the post-contract stage, progress billing can be monitored with more understanding between parties. Variations can be easily and consistently assessed with less time and dispute. This is because all the requirements referred to in the rules of measurement for pricing of each item of building services would have their legal implications as may be defined by the standard forms of contract used for the entire project.

In addition, in the context of handling overseas projects where there are cultural differences in language communication, building service BoQ is most advisable so as to avoid misunderstanding. The primary interest of all clients of the industry is to get the project implemented according to plan and within budget. Clients will be assured that their contract with the prospective contractor has been subjected to thorough and fair evaluation and they will get more definite value for his money. There is a real need to provide a uniform basis for measuring and valuing of building engineering services.

7 RULES OF MEASUREMENT AND BUILDING INFORMATION MODELLING

Building Information Modeling (BIM) is an emerging technology with huge potentials for automated quantity extraction from 3D drawings. Eastman et al., (2011) considered that for cost consultants to tap this potential and collaborate in a BIM model environment, they must identify a method that work best for their specific estimating process because there is no BIM tools that provides the full capabilities of estimating packages. The three subprocesses surrounding cost modeling and management from BIM models that could be applied at any stage of design development as identified by (Boon & Prigg, 2012) are:

- The extraction of the quantities of work to be done from the 3D model and arranging those quantities for estimating purposes
- The addition of costing data and the calculation of cost
- The derivation of costing data from libraries (or databases).

Similar to conventional practices by cost consultants, quantity extraction is also performed several times during the project but there is difficulty in extracting quantities in line with the rules of measurement. This is because, there is no alignment between the trade based rules of measurement and

estimating model in BIM (Boon, et al., 2011). This may be because in BIM environment, the information model and represents data under different domains. Meanwhile some domains have physical data types. While the rules of measurement can only be modeled using 'process model' which requires an abstract data type objectification to ensure that it is incorporated in the schema (Matipa, et al., 2010).

However, the Singaporean Construction Electronic measurement standard seems to have laid the foundation for adoption in model-based quantity extraction and estimating. This is because the rules of measurement in CEMS have clearly defined the requirements for Industry Foundation Class (IFC) for the resource layer. The resource layers that is important for measurement and costing. In the foreword to the CEMS, it is stated that "*CEMS adopts the format of works section classification .... in addition to the incorporation of Information Technology requirements for Automated Quantity Take-off System (AQTS)*. The standard is also aligned with the Singapore Code of Practice for the Classification of Construction Cost Information to ensure that construction cost information is structured and stored in a way that is consistent and reliable for use among project participants. In Malaysia the rules of measurement are still based on the provisions of SMM2 which is a still in prose format. Although the Royal Institution of Surveyors Malaysia has set up SMM3 committee but the classification system may still have to be aligned with British Standard Method of Measurement. However, this could make it difficult for Quantity Surveyors/Cost Consultants to fully collaborate with other professionals in BIM environment.

8 CONCLUSION

In order to overcome the problems of data quality and the absence of M&E services cost information in a standard and required format, it is necessary to create a framework that will enable the construction industry to maintain M&E service project cost information in a common format. The adoption of Standard Method of Measurement for M&E services can make a considerable contribution in this direction. In essence, there may be a need for the industry stakeholders to establish and adopt SMM for preparing BoQ for BES services so as to reduce the risk of price uncertainty and achieve better value for client's money in a rapidly transforming economy. SMM for BES services will provide home-ground advantage for practitioners and will go a long way in preparing building services subsector in the Malaysian Construction Industry for the challenges of planned liberalization of the services sector of the economy. However, to achieve this, the following should be considered:

There should be a concerted effort from industry stakeholders and academia to develop an academic framework to underpin cost management of BES services in buildings. Specifically, there is need for M&E quantity surveyors take charge of the cost management of building services in collaboration with M&E design consultants, this is the current trend in countries like the United Kingdom, Australia and Hong Kong. Some multidisciplinary consultancy organizations in Singapore and Malaysia are already leading the way in this practice, by employing specialist M&E quantity surveyors and providing these services to their clients as part of cost management service. Therefore, integration of this type of practices should be encouraged by the appropriate policy framework in the context of Malaysian Construction Industry. In addition, there is a need to improve on the background training of engineers in the areas of building services as the current university curriculum in the country does not give adequate consideration to the specific knowledge of building engineering services and therefore the subject of building services was not fully delve into in the background training of engineers . It is therefore, important, to emphasis on developing building engineering services as a special discipline away from current practices where knowledge of building services is only fully acquired in practice. This will make it possible to institutionalize professional body like Chattered Institute of Building Services Engineers (CIBSE) as obtains in the United Kingdom.

Development of national standards for uniformity in pricing items of BES is essential. This will require high level collaboration between key industry stakeholders to come up with a Standard Method of Measurement that will reflect local practices and standards. Strategies to encourage practitioners to adopt SMM for M&E services should also be instituted. This standpoint is necessary because, the current SMM2 is still in prose format which is years behind what is obtainable in other countries like Singapore, United Kingdom, Australia, and Honk Kong where the Common Arrangement of Work Sections (CAWS) has been adopted as framework to classify SMM information in tabular format that will aid application of Information and Computer Technology (ICT). Similarly, the use of Building Information Modelling (BIM) for estimating purposes will require filtering BIM data to comply with the rules of Standard Method of Measurement.

A strategy should also be developed to involve the major downstream supply chain at the inception of the M&E service project to reduce the risk of incomplete design information.

The application of Value engineering is essential in processing clients' requirements on major BES components at the inception stage of

building projects. This will ensure that quantity surveyors and M&E design consultants collaborate early on building services projects to consider the cost implications of various design alternatives before the selection of the best alternative that will meet clients' value criteria. This constitutes a useful approach for BES services and will minimise buildability problems at post contract stage.

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