

A Review of Value Creation from Procurement Contracts and Business Models for District Cooling Systems In Malaysia

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Abstract—A District Cooling System (DCS) is the favoured Air Conditioning System for buildings or facilities which have a large-scale cooling energy demand. The benefits offered by a DCS and the great support from the right wing of the Government of Malaysia's Economic Planning Unit (EPU) have given big opportunities for all the players in the Air-Conditioning-Engineering-Based Industry to enter and become established in this business. This paper reviews the definition of a DCS; the categories of air conditioning systems; the advantages of a DCS and the list of completed and ongoing projects and business models over the past forty (40) years in Malaysia. This paper also reviews the definition of the business model and procurement, the procurement choices in DCS and the lifecycle of a DCS. Further, it reviews the relations between the parties involved in this business and the procurement contract types and lifecycle in the district cooling business. In discussion, the value creation from this business is discussed based on three (3) main elements: the economic; the social impacts and the knowledge and technology. Therefore, it is hoped that the findings could assist the Government Link Company (GLC) and the private sector players in this industry to make appropriate decisions about the best procurement mode and the best business model that will benefit their respective interests, whilst at same time providing benefits to the client and the end-user, as well as to the general public, as users involved in implementing the DCS.

(District Cooling System; Procurement; BOO; Business Model; Value Creation)

I. INTRODUCTION

A District Cooling System (DCS) can be viewed as one of the air conditioning systems currently being applied to meet the large-scale air conditioning requirements of buildings. Nowadays, DCS is applicable to offices, hospitals, shopping malls, educational campuses, hotels, data centres, conference/exhibition centres, airports, places of worship, museums, theatres, archives and many other types of buildings. The system can be applied in new developments as well as retrofit projects.

The tropical rainforest countries like Brazil, Brunei, Colombia, Indonesia, Malaysia, Peru and Sri Lanka have

almost no distinct seasons with the average temperatures being typically around 27°C throughout the year. Hence, the comfort provided by air conditioning in these countries is almost compulsory, especially for commercial areas. The climate is the main factor supporting business in the air conditioning industry generally, as well as in the district cooling business.

The Economic Planning Unit (EPU) is a principal Malaysian government agency responsible for the preparation of development plans for the nation. In their guidelines in 2005, the EPU categorized an air conditioning system for more than 2,000RT (Refrigerant Tonnage) as a large air conditioning system and strongly recommended that such a system must apply for a DCS.

In Malaysia, the procurement choices in the district cooling business are various. However, the conventional forms of contracting, such as Engineer-Procure-Construct-Commission (EPPC) and Operation & Maintenance (O&M), are still largely implemented. The new innovative approaches to procurement that have been introduced since the 1990's include Build-Operate-Transfer (BOT), Build-Operate-Own-Transfer (BOOT), Rehabilitate-Operate-Maintain (ROM) and Build-Operate-Own (BOO).

There are many reasons why the implementations of the procurement system differ. For example, each of the procurement modes is integrated with a particular business model which has its own advantages and disadvantages, thus it is important to understand which business model best suits each procurement mode. The main methodology used in this paper study is based on a review of the literature.

II. DISTRICT COOLING SYSTEM (DCS)

A. Introduction of DCS

DCS is usually acknowledged as the term which represents a plant, system, scheme, concept or technology in the perception of professional parties within the Malaysian Air Conditioning Engineering industry. Currently, the scholars

have several definitions of a DCS, for example, Chow (2009) asserted that a DCS is a massive cooling energy production scheme in which chilled water is produced in a remote central chiller plant and is delivered to serve a group of consumer buildings through a closed-loop piping network.

Additionally, Danny Harvey (2010) stated that district cooling can save energy due to the more efficient operation of large centralized facilities that is possible and through the opportunities that district cooling provides to make use of low-temperature heat sinks. According to Chow et al., (2004), DCS offers massive and collective cooling energy production which is higher in efficiency than the conventional plants at individual premises and allows users to utilize building space more effectively.

DCS also has been referred to as a District Energy System (Marc et al., 2004), a Chilled Water Plant System (Wayne, 1996) or a Centralized Cooling Plant System (Bourdouxhe, 1997). DCS can be designed to integrate with a Thermal Energy Storage (TES) System and in some other places DCS is part of a Cogeneration System, a Tri-Generation System and a District Heating Cooling System (DHCS).

B. Categories of Air Conditioning System

The EPU guidelines in 2005 categorized the types of air conditioning system (EPU Guidelines, 2005) based on the design cooling capacity of an air conditioning system which was divided into six (6) categories using the design capacity in Refrigerant Tonnage (RT) as the unit of comparison. **Table 1** below shows the categories of system as per the EPU Guidelines.

Table 1: Types of Air Conditioning System (adapted from EPU Guideline, 2005)

No	Type of Air Conditioning System	Common Use	Design (Capacity RT)
1	Window or Split Unit	Small room or space only	< 5
2	Air Cooled Package Unit	Small spaces that have difficulties in obtaining a water supply	5 - 20
3	Water Cooled Package Unit	Medium system	20 - 40
4	Air Cooled Chilled Water System	Medium system	40 - 100
5	Water Cooled Chilled Water System (a) Conventional (b) with Thermal Energy Storage	Large System	> 100 > 500
6	District Cooling	Large System	> 2000

C. Advantages of DCS

The DCS provides cooling energy or chilled water through a central plant serving multiple buildings or huge developments. The advantages of DCS are as follows:

- a) *Lower electricity consumption cost;*

- b) *Lower electricity maximum demand;*
- c) *Reduced air conditioning costs;*
- d) *Economies of scale by lowering capital cost and production cost per unit of cooling energy;*
- e) *Higher plant efficiency by installing larger and more efficient equipment;*
- f) *By having centralized plant, the operation and maintenance work is easier and more economical;*
- g) *Space saving for the building owner; and*
- h) *Environmentally friendly. (adapted from TNEC Slide Presentation)*

Figure 1 below illustrates the typical DCS. For the conventional cooling system, each building will have its own, separate cooling system.

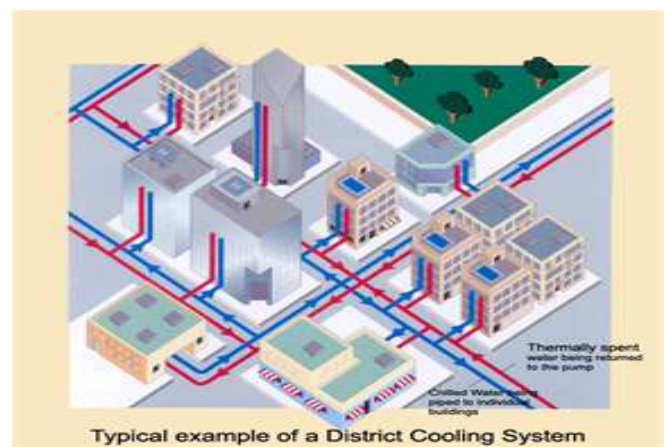


Figure 1: Typical Example of DCS

D. DCS Implementation in Malaysia

The DCS system has been applied in many project developments in Malaysia. The long list of District Cooling Plants in Figure 2 below shows that the system has been rapidly applied in related government and private projects in the Klang Valley over the last four (4) decades.

The increasing numbers of projects implementing a DCS shown in **Figure 2** above demonstrates that the system has already been accepted and implemented widely in the Malaysian market. With more developments to come from year to year, DCS construction and management has become an attractive business with great potential.

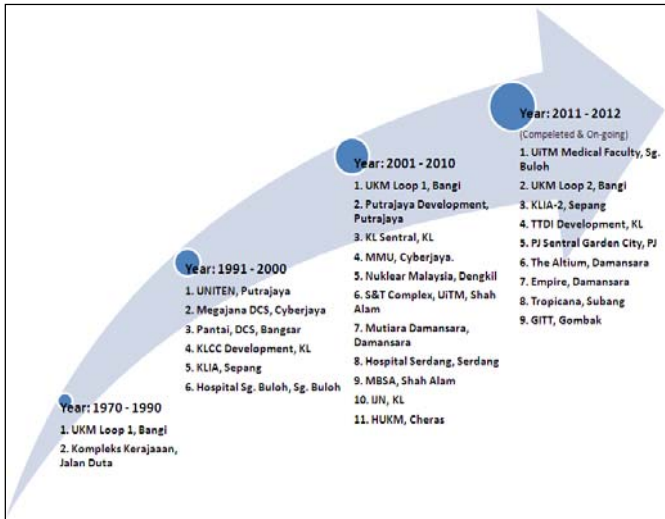


Figure 2: Timeline of DCS Projects in Malaysia

III. BUSINESS MODEL, PROCUREMENT CHOICES AND LIFECYCLE FOR DCS

A. Definition of the Business Model

Scholars have various perspectives in defining the business model concept (Steward and Zhao, 2000; Applegate, 2000; Morris et al., 2005; Timmer, 1998; Afuah, 2004). At a general level, the business model has been defined as a structural template (Amit&Zott, 2001) and as a conceptual tool or model (Teece, 2010).

According to Amit and Zott (2001), the business model depicts the content, structure and governance of transactions designed so as to create value through the exploitation of business opportunities. On the other hand, Teece (2010) stated that a business model articulates the logic, the data and other evidence that support a value proposition for the customer and a viable structure of revenues and costs for the enterprise delivering the value.

B. Definition of Procurement

At a general level, the procurement has been defined as a process, a cycle, a method or a set of activities (or system). According to Emmett and Sood (2010), procurement is also known as buying, sourcing, or purchasing, in the organizational process through which all products, materials, labour and services enter the supply chain from the various economic sectors.

Additionally, Straesser (2009) stated that the procurement process is also called the purchase-to-pay cycle. On the other hand, the USA-National Cooperative Highway Research Program (2006) defined procurement as the best-value contracting method. According to Dobler& Burt (1996), procurement is defined as a set of purchasing activities with tactical importance while Tempelmeier (1995) defines procurement as any activity within a firm aiming at supplying it with needed factor inputs.

C. Procurement Choices in the Construction Industry

According to Walker and Hampson (2003), the main procurement choices in the construction industry can be divided into four (4) categories as describe in Table 2. With each of the procurement choices having their own advantages and disadvantages, the right selection of procurement method is important in the lifespan of a DCS. The owner, originator or the party who identified the need for the system is having the biggest opportunity to decide on the procurement method to be implemented.

Table 2: Procurement Choices (adopted and summarized from Walker & Hampson, 2003)

No	Procurement Choice	Description
1	Fixed price contracting	<ul style="list-style-type: none"> Traditional procurement option Procurement process involves discrete design development, tendering, contract award and construction delivery phases.
2	Total package options	<ul style="list-style-type: none"> BOT, BOOT & BOO The 'B' represents the word 'built', the first 'O' as 'operate', the second 'O' as 'own' and the 'T' as 'transfer'. Procurement process involves design, build, operate, own for some period of time and transfer back to the owner.
3	Design and construct, renovation and turnkey	<ul style="list-style-type: none"> Procurement process involves design and construction.
4	Construction management (CM) & project management (PM)	<ul style="list-style-type: none"> For CM, the contractor acts as consultant builder providing significant advice on the practicality of the design and construction methods expected to be employed. CM is one of the non-traditional procurement methods. For PM or CM/PM arrangements, the CM shares design development input with PM. Recently, PM has been applied to house owner project teams.

D. Lifecycle of a DCS

The procurement choices and business models of the DCS are closely related to the DCS lifecycle and is the same as that adopted from the total asset management lifecycle. Figure 3 below illustrates the lifecycle of a DCS.

The lifecycle of a DCS is divided into four (4) main phases and comprises nine (9) stages:

- Phase 1: DCS Planning Phase** - The need for a DCS is identified. Then, the DCS is planned and designed.
- Phase 2: DCS Realization Phase** - The DCS is procured, built and commissioned.
- Phase 3: DCS Use Phase** - The DCS is used, operated and maintained.
- Phase 4: DCS Decommissioning Phase** - The DCS operation is stopped when the service is no longer needed or of economic use (adapted from Manual PAM, 2009).

decides their business model approach in the district cooling business.

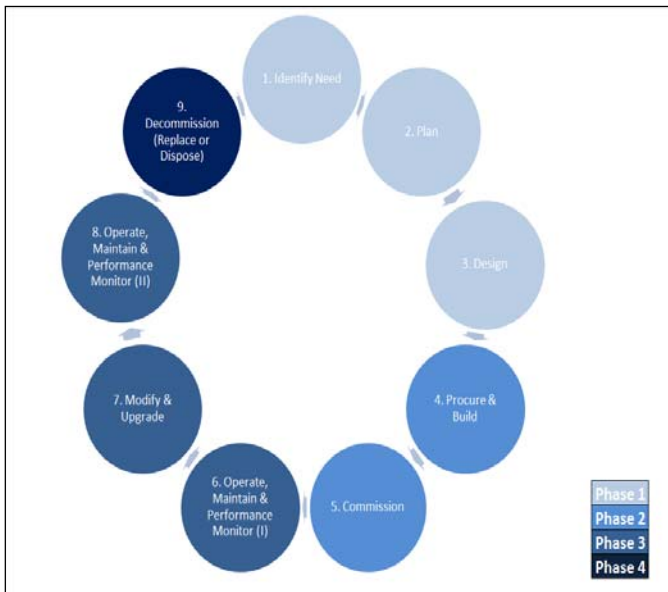


Figure 3: The Phases and Stages in the Lifecycle of a DCS (adapted from Manual PAM, 2009)

IV. PARTIES INVOLVED AND CONTRACT TYPES IN THE DISTRICT COOLING BUSINESS

A. The Parties Involved in the District Cooling Business

Within the context of this study, the parties that might be involved in a district cooling business are defined as follows:

- a) The DCS Owner;
- b) Engineer-Procure-Construct & Commission (EPCC) Contractor;
- c) Investor or Financier; operated and maintained.
- d) Operation & Maintenance (O&M) Contractor;
- e) Build-Operate & Transfer (BOT) Contractor
- f) Rehabilitate-Operate & Maintain (ROM) Contractor;;
- g) Build-Operate-Own & Transfer (BOOT) Contractor;bgf
- h) Build-Operate & Own (BOO) Contractor and;
- i) Building Operator or Building Owner.

B. Contract Types in the District Cooling Business

Within the context of this study there are six (6) common types of contract. **Table 3** shows the link between procurement choices and the contract types. The organizations involved in the district cooling business can participate in the business based on their capacity. They must decide on which procurement choices or contract types they favour. This choice

Table 3: Procurement Choices and Contract Types in the District Cooling Business

No	Procurement Choice	Contract Type
1	Fixed price contracting	EPCC
2	Total package options	BOT, ROM, BOOT, BOO
3	Design and construct, novation and turnkey	EPCC
4	Construction management (CM) & project management (PM)	EPCC
5	Operation and maintenance contract	O&M

i. Engineer-Procure-Construction & Commission (EPCC) Contract

According to Greenhalgh & Squires (2011), the engineer, procure, construct (EPC) or turnkey system is, as the name implies, a method whereby one organization, generally a contractor, is responsible for the total project from engineering design through to the point where the keys are handed over to the client as a fully operational facility. The responsibility of the contractor is therefore extended to include the installation and commissioning.

In the district cooling business, the DCS Owner subcontracts the EPCC contract during:

- a) The modify and upgrade stage; or
- b) The decommissioning stage.

Normally, the DCS Owner is also the Building Owner and Building Operator. The duration of works varies but normally much depends on the design, capacity, project difficulties, technologies and programme coordination.

ii. Operation & Maintenance (O&M) Contract

According to Delmon (2005), the O&M agreement will involve the management and operation of the project, providing maintenance, replacing materials and equipment and receiving and managing inputs. The owner may contract with an O&M Contractor, also known as the Operator.

The DCS can be operated and maintained by the owners themselves, who have expertise on the system. But for the owners who are not in this business and who need to focus in their core business, most of them decide to outsource the operation and maintenance (O&M) works to the O&M Contractor. The DCS Owner also owns the buildings.

The duration of an O&M contract is normally one (1) to three (3) years, which is considered to be a short-term service contract. The O&M Contractor who gives

the best value in terms of price during the tendering stage will normally win the contract. But, there are some owners who prefer the contract to be renewed every month with the contractor working on an on-call basis.

iii. **Build-Operate & Transfer (BOT) Contract**

According to Bult-Spiering and Dewulf (2006), under a BOT contract, the private sector finances, builds and operates a facility or system according to performance standards set by the government or owner for time periods ranging from ten (10) to twenty (20) years.

In this type of contract, the owner is subcontracting the EPCC and O&M Contractors to undertake the development of DCS which involves the planning, construction, operation and maintenance stages in an agreed period of time. Normally, the DCS Owner is also the Building Owner and Building Operator.

In this contract, the EPCC Contractor, the Financier and the O&M Contractor are normally the same party or sometimes can be a joint venture company (JV) or special project vehicle (SPV). The BOT Contractor will invest in the DCS development.

iv. **Rehabilitate-Operate & Maintain (ROM) Contract**

The nature of a ROM contract is very similar to the BOT contract. The difference between these two types of contract is that the BOT Contractor is engaged during the planning stage while the ROM Contractor is generally engaged during the modifying and upgrading stage of the system. The BOT contract corresponds to a Greenfield project (Organization for Economic Co-operation and Development (OECD), 2009) while the ROM contract corresponds to a Brownfield project.

This contract can only start when the owner decides to upgrade, retrofit, replace or rehabilitate the system. Normally, the owner is also the Building Owner and Building Operator. The ROM Contractor will finance the DCS rehabilitation works.

The payment mode for a ROM contract is similar to that for a BOT contract. The duration of the contract and payment is still long-term, between five (5) and ten (10) years, but shorter than a BOT contract. Once the contract period ends, the system is handed back to the DCS Owner.

v. **Build-Operate-Own & Transfer (BOOT) Contract**

According to the OECD (2009), under a BOOT contract or scheme, the private sector obtains the capital needed for construction; builds and operates the infrastructure, facility or system for an agreed period of time (anywhere between fifteen (15) and thirty (30) years) and then transfers ownership back to the relevant government or owner.

The nature of a BOOT contract is also very similar to a BOT contract. In a BOOT contract, the BOOT

Contractor usually invests almost the entire development cost. The ownership for the DCS is transferred to the BOOT Contractor for an agreed period. Normally, the owner is also the Building Owner and the Building Operator.

The payment mode for a BOOT contract is similar to BOT and ROM contracts. The duration of contract and payment is on a long-term basis, normally up to a maximum of twenty (20) years in the district cooling business. Once the contract period ends, the system is handed back to the owner.

vi. **Build-Operate & Own (BOO) Contract**

According to the OECD (2009), a BOO contract or scheme is similar to BOT except that it does not involve a transfer of assets to the public sector or owner after a pre-determined period of time. The private operator thus remains responsible for carrying out all the investment required to meet its service obligations.

The BOO contract is the most unique contract compared to the others since the owner is taking on the entire roles of the EPCC Contractor, the Financier and the O&M Contractor during the lifespan of the DCS.

The payment mode for a BOO contract is generally similar to the other total package option contracts. The main clients for this type of contract are the Building Operator and/or the Building Owner. The BOO contractor will supply the cooling energy to these clients. The duration of the contract and payment is long-term, normally for a maximum of twenty (20) years, and this contract normally continues as long as the DCS can operate economically.

C. Lifecycle and Business Model of District Cooling Business

Table 4 provides a summary of the duration for each contract type in the district cooling business. The contract type and duration highly depends on design, capacity, project difficulties, technologies and project coordination. The business model of the DCS is closely related to the DCS lifecycle, which is the same as the asset lifecycle. **Figure 4** illustrates the lifecycle of a DCS and the contract types.

In Malaysia, the contract type when implementing a DCS varies. However, most contracts use traditional procurement choices, which are EPCC and O&M. **Table 5** shows the DCS project in the Klang Valley, Malaysia along with the contract type used.

Table 4: Duration for Each Procurement Contract Type in the District Cooling Business

No	Contract Type	Duration
1	Engineer-Procure-Construct & Commission (EPCC)	1 year – 3 years
2	Operation & Maintenance (O&M)	Various: - Monthly basis - Yearly basis - Every 2 years
3	Build-Operate & Transfer (BOT)	10 years – 20 years
4	Rehabilitate-Operate & Maintain (ROM)	5 years – 10 years
C5	Build-Operate-Own & Transfer (BOOT)	15 years – 20 years
6	Build-Operate & Own (BOO)	20 years and more

Table 5: Selected DCS Projects and the Contract Type in the Klang Valley, Malaysia

No	Project Name	Contract Type Used					
		EPCC	O&M	BOT	ROM	BOOT	BOO
1	UKM Loop 1, Bangi	√	√		√		
2	Kompleks Kerajaan, Jalan Duta	√	√				
3	UNITEN, Putrajaya	√	√				
4	Megajana DCS, Cyberjaya						√
5	Pantai DCS, Bangsar						√
6	KLCC Development, KL						√
7	KLIA, Sepang	√		√			
8	Hospital Sg. Buloh, Sg. Buloh	√	√				
9	Putrajaya Development	√					√
10	KL Sentral, KL						√
11	MMU, Cyberjaya	√	√				
12	Nuklear Malaysia, Dengkil	√	√				
13	S&T Complex, UiTM, Shah Alam	√	√				
14	Mutiara Damansara, Damansara	√	√				
15	Hospital Serdang, Serdang	√	√				
16	MBSA, Shah Alam	√	√		√		
17	IJN, KL	√	√	√	√		
18	HUKM, Cheras	√	√				
19	UiTM Medical Faculty, Sg. Buloh	√	√				
20	UKM Loop 2, Bangi	√	√				
21	KLIA-2, Sepang			√			

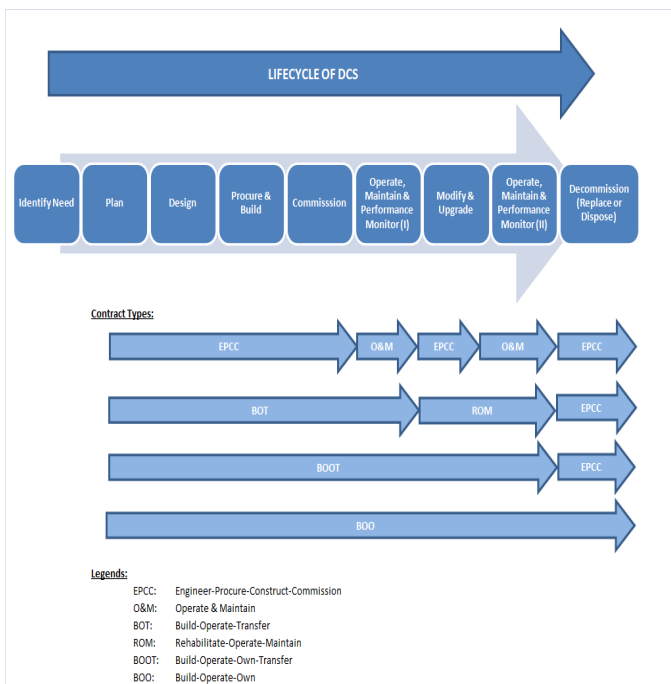


Figure 4: Lifecycle of a DCS & the Contract Types in the District Cooling Business

V. DISCUSSION

A. Value Creation and Withdrawal from Different Contract Types in the District Cooling Business

In the context of this study, the value creation from different contract types in the district cooling business can be viewed from the perspective of the parties involved. Three (3) elements of value creation are selected to compare the value created or with drawn by each contract type. These are: economic, social impact and technology & knowledge.

i) Element 1 – Economic

EPCC and O&M contracts are the most common types of contract used but the revenue comes in the short term compared to total package option contracts (or BOT, ROM, BOOT and BOO contracts). The competitive price during the tendering stage for EPCC and O&M contracts is the most important factor in winning the contract while the package contracts can be more flexible and subject to the agreement of all the parties involved.

For EPCC and O&M contracts, the owner looks for the contractor who can give them the best value, which is normally the contractor with the lowest cost. The competition between contractors has results such as:

- a) *Slim profit margins for contractors;*
- b) *the quality of equipment, resources and service delivery can be jeopardized;*
- c) *cost overruns in constructions and O&M services; and*
- d) *delays in construction.*

Unlike the BOT, ROM, BOOT and BOO contracts, the risk rests with the contractor side because they need to raise sufficient capital to meet the cost. The revenue and profit normally come into the picture during the O&M period which is after the construction has been completed and commissioned. A good financial model is very important for both parties in ensuring their long-term contract will result in a win-win situation.

The main factor for the contractor is that the client must be a good paymaster to ensure that the payments are secure. The contractor may not be interested in entering into a long-term contract with a high-risk client since clients with bad payment habits can cause problems to the contractors, such as making it difficult to:

- a) *Pay their loans to the Financier;*
- b) *Cover construction expenses; and*
- c) *Cover O&M works expenses.*

It can also lead to:

- d) *Disputes over the contract; and*
- e) *Losses to the contractor.*

On the other hand, the the owner's biggest concern is the availability of reliable and sufficient cooling energy supplies during the operational business hours. If the contractor fails to provide as per the contract or agreement, this will impact on the owner and building operator by:

- a) *Disturbing business operations;*
- b) *Causing the loss of important clients; and*
- c) *Leading to losses to the owner.*

ii) Element 2 – Social Impacts

The EPCC & O&M contracts create many contractor jobs compared to the package contracts such as BOT, ROM, BOOT and BOO which appear to have monopolized the business. The trend of development in the future is going towards the package contracts because they offer the owner more benefits such as:

- a) *Reduced capital cost;*
- b) *Reduced design time and cost;*
- c) *Reduced procurement time and cost;*
- d) *Reduced operation and maintenance cost;*
- e) *A green environment; and*
- f) *A guaranteed level of service.*

In terms of contract duration, the EPCC and O&M works are considered as short-term works, which can produce a high overhead burden for the contractors. Moreover, failure to win a contract or the need to get out of a contract can also impose significant costs. Most of employees working with these contractors are on a contract basis. Permanent employment is a big risk for the employer in terms of overhead costs whilst, for the employee, the career path is undefined and insecure.

Package contracts, on the other hand, are long-term contracts in which the contractors can be more flexible in covering their overhead costs. The employment strategy can become more flexible and the employees can be a combination of contract and permanent employees. The career path of employees in these types of contract is better and more secure compared to those working for traditional contractors.

The manpower required by the owner is reduced if they choose the package contract option because, compared to the traditional contracts, the supervision, monitoring and procurement work for the BOT, ROM, BOOT and BOO contracts is appreciably less. This allows the owner to give full attention to their core business.

iii) Element 3 – Technology & Knowledge

For EPCC & OM contract types, the technology and knowledge are transferable from the contractors to the owner. The owner needs to monitor and control the contractors and they need to be as knowledgeable as the contractors. The owner with less technical knowledge will find monitoring and controlling their contractors difficult.

However, owners who use the total package option need to be less worried about technology and knowledge because they only begin to control the system after the system is handed back to them, except for a BOO contract. The technology and knowledge transfer from the contractors to the owner is minimal.

VI. CONCLUSIONS

Based on the increasing number of DCS projects since 1970, the implementation of large-scale air conditioning systems or DCS in Malaysia appears to be a growth industry. The support from EPU and the Government for DCS systems has also catalysed this business.

The procurement choices in implementing the system are still open to the traditional contract, such as EPCC and O&M, and the new innovation of the total package option such as BOT, ROM, BOOT and BOO contracts. The selection of the procurement contract remains with the owner and the contractor can decide on their own business approach. The contractor approach in selecting the type of contract that they favour has become a business model for them to create value for their organization and their clients.

In conclusion, the authors found that the BOO contract has considerable advantages compared to the others and suggest that the BOO contract will be the best future procurement contract type in Malaysia. The selection of this type contract is based on the following reasons:

- a) *The nature of the contract provides considerable support to the Governments' Total Asset Management and Green Policies;*
- b) *On the owner side, the owner can focus on their core business; reduce capital cost with opportunities to achieve zero entry cost and fewer construction and O&M issues; and*
- c) *On the contractor side, the contract will generate long-term revenue, which will give significant support to their business survival.*

No type of contract or technology can guarantee success if the DCS system fails to meet the financial capabilities of the user. Therefore, it is important to undertake financial modelling to understand the relationship between the financial capabilities, types of contract and the DCS technology before implementing the system. The success of the DCS implementation depends on the right business model, positive financial capabilities and the ability to meet the user's needs. This will be the subject of future research.

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