
Pan Lee and Patrick T. I. Lam*

Department of Building and Real Estate, The Hong Kong Polytechnic University, Hong Kong, China

Abstract: Energy Performance Contracting (EPC) projects provide building owners (the client) with a turnkey retrofit in their existing buildings as energy service company would assist clients to identify energy saving potential, design and install energy conservation measures (ECMs), monitor performance of installed ECMs, as well as train operators for better system operation. In order to promote the wider use of EPC, this paper proposes a model of EPC which enables building owners and energy service companies to identify and address the key issues when implementing EPC projects, starting from the stage of pre-retrofit, installation, to post-retrofit. This proposed model is developed based on the extensive literature review, questionnaire survey findings, as well as semi-structured interviews with the key stakeholders in Hong Kong. The model consists of 12 Building Blocks, including risk assessment of energy saving shortfall and contract management.

Keywords: Energy Performance Contracting, energy service company, retrofit, energy, building

DOI: 10.7492/IJAEC.2015.011

1 INTRODUCTION

Energy Performance Contracting (EPC) is a contracting model between building owners (the Client) and energy service companies (the ESCO), whereby the ESCO identifies energy saving potential, designs and installs energy conservation measures (ECMs), monitors performance of installed ECMs, as well as trains the operators for better system operation (Bertoldi et al. 2006).

In some EPC arrangements, the ESCO may pay up-front cost for design and installation work, and share the energy saving resulting from the installed ECMs during the contract period. As such, this contracting model is particularly useful for the clients who lack up-front capital and technological know-how for project implementation. To ensure that the expected energy savings can be actually realised, the ESCO may guarantee the client for an agreed level of energy savings. In case of saving shortfalls, the ESCO will compensate the losses incurred by the client under the contract agreement.

EPC has been widely used around the world (Marino et al. 2011). In the United States, the Federal Government has extended the commitment of entering into a total of US 4 billions of energy saving performance contracts by the end of 2015 (DOE 2012). In the UK, an EPC scheme (called RE:FIT) has been launched in order to provide a commercial model for public sector to implement building retrofitting projects (DOECC 2015). Similar to many Asian cities, in Hong Kong, the take-up rate of EPC is still relatively low (Davies and Chan 2001). The ESCO industry is not proactive to implement measures, for examples, development of EPC procurement and local measurement & verification (M&V) guidelines. In the public sector, only a few pilot EPC projects were conducted in police stations, hospitals and a game hall (EMSD 2013).

In order to promote the wider use of EPC, this paper proposes a model of EPC which enables building owners and ESCOs to identify and address the key issues when implementing EPC projects. The model is based on the findings obtained in Hong Kong, which is a metropolitan city with a high level of energy intensity, especially in the commercial sector.

2 A CONCEPTUAL MODEL OF EPC

A conceptual model of Energy Performance Contracting (EPC) has been developed based on extensive literature review, questionnaire survey findings, as well as semi-structured interviews with the key stakeholders in Hong Kong. The launch of questionnaire sur-
vey was aimed at investigating the current development of EPC market in Hong Kong. Questions in relation to risk allocation and typical arrangement in EPC projects were asked to respondents including 168 building owners (representing a response rate of 18.9%) and 34 ESCOs (representing a response rate of 24.8%). Moreover, twenty-one interviews were conducted with different stakeholders, including 6 ESCOs, 8 building owners and 2 relevant associations. The findings of interviews are used as a supplement to the questionnaire survey. (Other details of questionnaire survey and interview findings can be referred to other published works of the authors).

The development of this conceptual model is intended to help building owners and ESCOs to identify and address the key issues when implementing EPC projects, starting from the stage of pre-retrofit, through installation, to post-retrofit. The model consists of 12 Building Blocks as shown in Figure 1. Each block is further sub-divided into several components for zooming into specific details.

2.1 Client’s Requirements

Apart from the basic requirements in conventional building retrofitting projects such as scope definition of work, constraints and functional needs (e.g. thermal comfort), the client’s requirements in EPC projects comprise targeted energy savings, risk allocation, ESCOs’ competence, financing needs, and operation & maintenance. Figure 2 summarises the client’s requirements in a typical EPC project. After those requirements have been clearly defined, the client may start the procurement process, which will be discussed in the next section.

2.2 Procurement Process

Figure 3 shows two approaches for EPC procurement: 1) solicited by building owners; 2) initiated by ESCOs. For the former, the building owner may issue a call for Expression of Interest (EOI), which mainly describes the client’s requirement. After receiving the response from the interested ESCOs, the building owner may invite the shortlisted ESCO(s) to conduct an investment grade audit (IGA), which would form a first-stage of EPC contract. It should be noted that more than one ESCO may be awarded the IGA contract(s). With the result of IGA, the ESCO(s) will propose the ECMs and expected energy savings, together with the means of project financing to the building owner for consideration. At this stage, the building owner may decide whether the proposed retrofit is implemented or not. If the building owner agrees the proposed retrofitting, both parties would negotiate the EPC contract and implement the project. If deciding not to proceed with EPC, the building owner may reimburse the cost of IGA to the participating ESCO(s).

For the latter, the ESCO would take an initiative to propose retrofitting solutions to the building owner. It is common that those ESCOs are the equipment manufacturers which periodically conduct maintenance work.

---

**Figure 1. A conceptual model of EPC**
in the building owner’s premises. When the building owner is interested in an ESCO’s preliminary proposal, the ESCO would further conduct IGA and submit a report. Similarly, the building owner would decide to either proceed with EPC contract or reimburse the cost of IGA to the ESCO.

During the stage of contract negotiation, the key issues which both the ESCO and client have to deal with are the determination of suitable EPC mode for project implementation, evaluation of probability of energy saving shortfalls, as well as contract management. These issues will be discussed in the next.
2.3 Investment Grade Audit

In comparison with conventional energy audit, investment grade audit (IGA) not only focuses on the review of building energy performance, identification of possible ECMs as well as cost-benefit analysis of proposed retrofitting solutions, but also emphasises on the expected level of energy savings if the proposed works are implemented. Hence, the IGA report would be more comprehensive and detail the method and procedures for development of energy use baseline, as well as measurement & verification plan. In addition, the ESCO would propose the means of project financing. In practice, the IGA report will often form part of the EPC contract when the host agrees with the works proposed by the ESCO, with refinements if necessary.

2.4 Choice of Suitable EPC Mode

Figure 4 outlines the approach and key issues to be considered for the selection of EPC mode. In general, there are two types of EPC mode, namely 1) Guaranteed Savings; 2) Shared Savings.

For the former, the ESCO would guarantee the building owner for a certain percentage of energy savings during the post-retrofit period. As the ESCO bears the performance risk in the guaranteed mode, the building owner usually pays the upfront cost or obtains a loan from financial institutions for project implementation. For the payment mechanism, two possible arrangements can be adopted in the guaranteed mode: 1) schedule payment; 2) payment is linked to actual savings, and both parties can incorporate excess savings and saving shortfall into the payment conditions.

Another EPC mode is shared savings where the ESCO and building owner would share savings with the agreed percentage during the post-retrofit period. In this shared saving mode, the ESCO often pays the upfront costs or obtain a loan from financial institutions. For payment, the amount of payment depends on the agreed percentage of actual savings between both parties.

In Hong Kong, it was observed that some ESCOs are willing to bear both performance and financial risks in EPC projects such that they can attract more customers to consider EPC as a means of building retrofitting. However, they mostly target those customers from the semi-public sector and developers who have strong credibility in repayment. In addition, the interviewees highlighted that the ownership of equipment is often transferred to the building owner upon the completion of installation, even though the ESCOs make the full payment for the equipment in advance. Such arrangement is to protect the interest of the building owner in the event of disputes, but the provision is often made that the ESCO can receive the termination value, which is linked to the remaining value of equipment, when the contract is terminated by the building owner.

![Figure 4. Building block D - Choice of suitable EPC mode](image-url)
2.5 Risk Assessment of Energy Saving Shortfall

As the ESCO would guarantee the building owner for a certain amount of energy savings, it is vital for both the ESCO and the building owner to understand the inherent risks in EPC projects and chances of having saving shortfalls during the contract period. It is proposed that a probabilistic risk assessment method be adopted for quantifying the probability of possible energy savings under the proposed ECMs by the ESCO. The whole procedures comprise five steps, namely ‘development of pre- and post-retrofit models’, ‘sensitivity analysis’, ‘development of probability function for the influential parameters’, ‘simulation of possible energy savings’ and ‘analysis of simulation results’. In order not to distract the depiction of the overall conceptual model, further details of the method and procedures may be referred to the authors’ other published works.

2.6 Contract Management

The essential provisions in an EPC contract include the mode of EPC, scope of savings, treatment of excess savings and saving shortfalls, performance commencement date, guarantee/saving period, additional ECMs, payment, financing, design liability, ownership of equipment, performance and guarantee bonds, operation and maintenance, dealing with risk of changes, assignment of rights and obligations, termination upon default, termination without default, as well as dispute resolution.

One particularly important issue is the provision for adjustment of energy use baseline since during the contract period, changes in occupation pattern, internal layout, weather conditions (affecting air-conditioning systems), etc. may occur. Such changes must be brought to the notice of the ESCO and adjustments need to be made to the baseline based on negotiation or some formulae laid down in the contract documents. Hence, reasonable access to the premises by the ESCO should be allowed.

A building owner with in-house technical support may oversee the contract, or solicit the advice of independent consultant. Otherwise, a reputable and trustworthy ESCO needs to be engaged for the works.

2.7 Design, Supply, Installation, Testing and Commissioning

Once the ESCO is appointed, the installation stage follows. This stage is similar to the conventional retrofitting projects, which involve design, supply, installation, as well testing & commissioning (T&C). During this stage, the ESCO shall submit the materials in respect of design drawings, installation plans, work schedule, for the building owner’s review and approval.

When the ECM work is not completed on the scheduled date, the building owner may claim the ESCO for liquidated damages or the ESCO requests for an extension of time due to the event(s) as set forth in the Contract. Once the ECMs are completed with satisfactory performance, the building owner would issue a Certificate of Substantial Completion, meaning that the post-retrofit stage commences. Figure 5 outlines the important elements in the stage of design, supply, installation and T&C.

2.8 Modification of ECMs

Although the ESCO fully complies with the contract specification to undertake installation works, the expected energy savings may not be fully achieved due to problems in system design and operation. According to the contract terms, the building owner would receive compensation in the event of saving shortfalls. However, this is not the main purpose of implementing EPC project. The building owner should be looking for long-term energy savings, instead of compensation.
Therefore, the ESCO may modify the installed ECMs or install additional equipment at the ESCO’s own cost in the stage of Testing & Commissioning. The ESCO may also exercise the modification option when the ESCO records consecutive saving shortfalls during the post-retrofit period.

2.9 Commencement of ECM Performance

The commencement performance date is an important milestone for the entire EPC project as it kicks start the monitoring and recording of the ongoing performance of ECMs, maintenance and repair of the ECMs (resulting from normal wear and tear). The ESCO also checks the compliance of said operation procedures, as well as calculate the accumulated savings. In general, the commencement performance date is the day after substantial completion. However, it was also observed in some EPC projects that the commencement of saving guarantee will be postponed to the date on which the first utility bill is issued after retrofitting. The main purpose of such an arrangement is to make the M&V work consistent with the issue date of utility bills.

2.10 Operation & Maintenance

Proper operation and maintenance for ECMs are essential to improve system efficiency and thereby maximise energy savings (Piette et al., 2001). To ensure that the staff complies with the said operation procedures, the building owner should grant the ESCO access to the premises for regular inspection. The ESCO should also provide regular maintenance on the retrofitting works. In the event of a failure in ECMs or metering devices, the building owner should promptly notify the ESCO of such a failure and request the ESCO to made necessary repair works. In Hong Kong, the ESCO is often responsible for maintenance works, whilst the building owner takes the control of system operation. This is because the building owner would like to ensure that thermal comfort would not be compromised in order to achieve the promised savings by the ESCO. Many commercial or institutional owners also have their in-house property management staff looking after the entire buildings.

2.11 Measurement and Verification

Measurement and Verification (M&V) work should be carried out with the consideration of those elements, including ECM intent, measurement boundary, baseline conditions, adjustment mechanism, reporting period, budgeting for M&V, as well as M&V option. For M&V option, the IPMVP guideline recommends four approaches to carry out M&V work, namely a) Retrofit Isolation: Key Parameter Measurement; b) Retrofit isolation: All Parameter Measurement; c) Whole Facility; d) Calibrated Simulation (EVO 2012). The guideline also provides several examples of system retrofitting to illustrate which option is preferable to be adapted. Figure 6 lists out the important elements in the typical M&V work.

It is noted that difficulties are found in determining accurate energy use baseline and adjustment mechanism in Hong Kong. This is due to the poor quality of measurement data from building management system (BMS) as observed in some existing buildings. In order to tackle this problem, it is common for the ESCO to undertake short-term measurements. Such on-site measurements enable the ESCO to develop the acceptable energy use baseline and determine the influential parameters which would trigger baseline adjustment when certain agreed percentages of changes are reached in those parameters (e.g. 5 percent of occupancy level).

2.12 Payment Mechanism

Figure 7 depicts two payment approaches which can be adopted in EPC projects. The first one is ‘scheduled payment’. Such payment arrangement is similar to conventional construction projects where both contracting parties would follow the payment schedule as set forth in a contract. In order to incorporate the concept of saving guarantee into the payment arrangement, the scheduled payment would be adjusted based...
on the agreed treatment of saving shortfall & excess savings. The main advantage of this payment arrangement is that both parties can understand the cash flow in advance for the entire period of EPC project.

The second payment approach is the payment linked to actual savings. In this arrangement, the amount of payment is calculated based on the actual cost savings being achieved by the ESCO, and the timing of payment is in line with the period of M&V. Besides, unlike the scheduled payment, no payment would be made to the ESCO before substantial completion, and this arrangement may limit to the scale of ECMs, especially for the small-medium ESCOs.

3 CONCLUSION

This paper proposes a conceptual model of EPC which enables building owners and ESCOs to identify and address the key issues when implementing EPC projects. The model covers three stages of an EPC project, namely, “pre-retrofit stage”, “installation stage”, and “post-retrofit stage”.

In the pre-retrofit stage, the key issues involved are the identification of energy saving potential, allocation of performance and financing risks, as well as contract management. It should be noted that different ESCOs may propose various retrofitting solutions. This makes comparison of bids not only dependent on price, but the expertise of building owners, their consultants (if engaged), ESCOs and therefore a set of prioritised requirements established by the owner is particularly important.

In the installation stage, apart from the basic elements in conventional projects such as review and approval of design drawings, installation plans and work schedule, attention should also be paid to whether the ESCO can deliver the promised energy savings after testing and commissioning. Although the ESCO would compensate the losses to the building owner in the event of saving shortfalls, for the sake of long-term energy savings, the building owner may request the ESCO to modify the installed ECMs or install additional equipment at the ESCO’s own cost.

In the post-retrofit stage, it involves operation and maintenance, and measurement & verification. In practice, the ESCO is often responsible for maintenance works, whilst the building owner takes the control of system operation. Both parties need to establish a good trusting relationship. Besides, in Hong Kong, the scheduled payment is the most common payment arrangement in EPC projects. This is because this payment arrangement enables both parties to understand the cash flow in advance for the entire period of EPC project. In case of saving shortfall & excess savings, the scheduled payment would be adjusted according to the agreed contract terms. It is worth noting that the M&V report often forms an important document for payment made by the building owner to the ESCO.

With the understanding provided by this conceptual model, it is expected that both building owners and ESCOs can better manage the key issues arising in EPC projects.

ACKNOWLEDGEMENTS

The work described in this paper was supported by a grant from the General Research Fund of the Hong Kong SAR Government (Project no. PolyU5188/11E).

REFERENCES

status and a strategy to foster their development.”


