Risks in Energy Performance Contracting (EPC) Projects

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Risks in Energy Performance Contracting (EPC) projects

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ABSTRACT

Compared with conventional energy retrofit projects, Energy Performance Contracting (EPC) projects present a different risk picture to the contracting parties as its primary focus is to deliver promised energy savings to building owners (hosts). This study aims to identify the key risks inherent in EPC projects, and investigate the hosts' concerns on the use of EPC, as well as propose practical measures to enhance the wider adoption of EPC. Two separate questionnaire surveys were conducted with respondents comprising ESCOs ($n = 34$) and hosts ($n = 168$) in Hong Kong. Results indicate that the key risks to ESCOs are possible payment default of hosts after installation, uncertainty of baseline measurement, and increase in installation costs in EPC projects. For hosts, their primary concerns in considering the use of EPC include possible long payback periods, project complexities and repayment ability. In addition, the respondents agree with three practical measures to enhance the adoption of EPC in future, including the promotion of successful projects, modification of government procurement practices, and government's backup of loans. The findings of this study provide useful pointers to key stakeholders of EPC projects for harnessing their risk perceptions and mitigating their concerns on this procurement approach.

1. Introduction

Energy Performance Contracting (EPC) has been widespread around the world and considered as an alternative way to improve energy efficiency (EE) in existing buildings [1,2]. In EPC projects, energy service companies (ESCOs) not only provide building owners (hosts) with the upfront capital for project implementation, but also monitor the actual performance of newly installed equipment and provide staff training for better system operation and control. In a popular EPC model, the ESCO guarantees the host a certain level of energy savings and compensates the losses in the event of a shortfall in savings [3].

A strong commitment from the government to the use of EPC has been observed in several countries [4]. In the U.S., extensive works and efforts, such as the development of standard contract documents, amendment of procurement procedures, as well as provision of project facilitators, have been made to foster the wider use of EPC in the public sector [5]. In Europe, an EU-Energy Performance Contracting Campaign (EPCC) was launched by the European Commission in order to assist member states in developing a legal and financial framework for the EPC market [6]. In Asian countries such as Singapore and Taiwan, various kind of financial schemes have been launched to promote the use of EPC for retrofitting existing buildings [7,8].

In comparison with traditional EE projects such as "fee for services" and "design-bid-build", EPC projects are plagued with performance and financial risks. In traditional projects where the construction and installation are completed by contractors in accordance with consultants' design, the only contractual benefit left to the host is a warranty of installed equipment during the operational period. In EPC projects, the contractual obligations, especially for the actual performance of energy conservation measures (ECMs), still remain with the ESCOs to ensure that the expected energy savings would be actually materialized. There are a number of factors affecting the successful delivery of expected energy savings, including the degradation rate of system performance, quality of system operation and maintenance (O&M), environmental conditions (e.g. change in weather pattern) as well as accuracy in estimating expected savings [9,10]. Since the ESCO often pays the upfront capital for project implementation, other aspects, such as ownership of equipment and payment arrangement, become critically important in risk management in EPC projects. In practice, unclear risk allocation in these aspects may lead to disputes and litigation [11].

Previous studies on risk management of EPC projects mainly focus on risk assessment tools and risk mitigation measures. Mills et al. [9] first identified the risks inherent in performance-based EE projects and classified them into five categories, namely

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economic, contextual, technology, operation, and measurement and verification (M&V) risks. Earlier on, Mills [12] suggested the use of energy-savings insurance to spread performance risks over a large number of EE projects. Mathew et al. [13] adopted the actuarial pricing approach to quantify the risks associated with EE projects. Jackson [14] and Lee et al. [15] proposed using the Monte Carlo technique for evaluating the probability of energy saving shortfall in EPC projects. In practice, risk allocation in EPC projects is often made through contractual procedures, for example, in the Federal EPC projects, completion of “Risk, Responsibility and Performance matrix” is a mandatory requirement to address the ESCO’s responsibilities on several key issues, including changes in interest rates and construction costs, M&V procedures, changes in operating patterns and load, as well as O&M [16]. However, previous studies associated with risk perception and concerns in EPC projects are rather limited.

The objectives of this study are: (1) to identify the potential risks in the whole life cycle of EPC projects; (2) to examine the risk allocation of EPC projects from the ESCOs’ perspective; (3) to investigate the concerns of contracting parties on the use of EPC; and (4) to evaluate the usefulness of practical measures to enhance the adoption of EPC. Therefore, in addition to risk identification, the findings of this study provide EPC practitioners with a clear understanding of important risk allocation factors and hosts’ concerns on EPC projects. Practical measures to enhance the development of EPC market are recommended. This paper consists of five sections: Section 2 provides the background information of EPC procurement, and risk identification. Possible measures to mitigate the associated risks are proposed. Section 3 presents the research methodology. Sections 4 and 5 contain the results and discussion. Finally, Section 6 draws a conclusion and recommends areas of further research.

2. Background

2.1. Energy Performance Contracting (EPC) projects

According to the Directive 2006/32/EC, the European Parliament defines EPC as “a contractual arrangement between the beneficiary and the provider (normally an ESCO) of an energy efficiency improvement measure, where investments in that measure are paid for in relation to a contractually agreed level of energy efficiency improvement” [17]. It means that EPC projects not only focus on design and installation, but also emphasize on the actual performance of new ECMs. This contractual arrangement entails the ESCO bearing all the performance risks of proposed ECMs. As such, other non-core works such as energy audit, testing and commissioning as well as maintenance become essential for the ESCO for a successful delivery of proposed energy savings. Apart from this, project financing is another unique feature in EPC projects as the host may implement the retrofitting project without upfront capital. Compared with conventional EE projects, this financial arrangement provides incentives for the hosts who lack funding to improve building energy performance in existing buildings.

In general, guaranteed savings and shared savings are two common models in EPC projects [18]. In the guaranteed saving model, the ESCO guarantees the host a certain level of energy savings if the proposed ECMs are implemented. When the actual energy savings are less than the guaranteed level, the ESCO would compensate such shortfall to the host. The host usually obtains financing from its own internal funds or a third party (e.g. a bank or financial institution). In the shared saving model, the ESCO provides financing for project implementation. In each M&V period, the materialized energy savings would be shared by both contracting parties based on an agreed percentage.

2.2. EPC procurement process

Singh [19] identified six key steps that are commonly involved in the EPC procurement process. These steps are budgeting, energy audit, request for proposal, bid evaluation, project financing, contracting, as well as measurement and verification (M&V).

Budgeting is the first stage of EPC projects when the initial costs will be estimated regarding the collection of information and data for an energy audit, assigning staff to develop the bidding documents and to supervise the project. After that, an energy audit follows. The host will issue a call for “Expression of Interest” (EOI) for the EPC project. The energy audit will then be conducted by the selected ESCOs to identify energy saving potential, estimate the amount of energy savings if the proposed ECMs are conducted, and investigate data sufficiency for developing the acceptable energy use baseline.

When the energy audit is completed, there are two ways to issue the “Request for Proposals” (RFP). First, the host invites the selected ESCOs to submit their EPC proposals based on their individual energy audit findings. Second, the host issues a RFP for an open competition among the interested parties. The ESCOs who have conducted the energy audit may or may not be involved. Their proposals are solely based on the information and data disclosed by the host. The main purpose of RFP is to define the general scope of work and specify the requirements associated with system design, method of installation, financing, O&M and M&V.

The EPC proposals returned from the bidders are then evaluated based on the criteria, including the proposed solutions, energy savings, investment cost, contract period and company competence. A committee of reviewers gives a score on every submitted proposal and negotiates the contract with the bidder who has obtained the highest score. The terms of project financing are sometimes difficult to be defined clearly at the tendering stage. The host will discuss with the bidder the method of financing, either from banks, financing institutions or self-arranged finance.

2.3. Risk identification in EPC projects

Mills et al. [9] identified the risks associated with EE projects and classified them into five aspects, namely economic, contextual, technology, operation, and measurement and verification (M&V) risks. Hu and Zhou [20] proposed another classification on the risks inherent in EPC projects, namely political and legal risk, market risk, technology risk, management risk, financial risk, project quality risk as well as client risk. Based on literature review, the risks associated with EPC projects are summarized in Table 1, with the additions of risk causes and consequences in the context of EPC as a particular type of EE projects.

2.3.1. Economic risks

Economic risks are the possible losses which result from variations in energy costs, demand charges, material costs, equipment costs and labor costs [20–22]. In most standard forms of EPC contract, a relevant clause is stipulated that both contracting parties bear the risk of variations in energy costs and demand charges, and the baseline of those costs will be adjusted accordingly when such variations occur [27]. However, in the guaranteed saving model, only the ESCO bears those risks. For the risk of variations in material costs, equipment costs and labor costs, it is common that the ESCO fully bears the risks associated with increases in those costs.

2.3.2. Financial risks

In general, there are two common types of financing approach in EPC projects, namely self-financing and third-party financing [18]. With the former, the host pays the upfront capital for project implementation, and the ESCO bears the performance risk by a guarantee

Table 1
EPC project risks and their management (expanded from Mills et al. [9] and Hu and Zhou [20]).

Risks	Manifested as	Risk causes	Risk consequences	Risk management
Economic risk	Construction cost increases	Labor/material volatility [21]	Reduction in profits of ESCO	Price adjustment based on indices
	Interest rate increases	Interest rate volatility in loan market [20]	Higher interest rates will increase financing cost	Interest rate swap
	Fuel cost increases	Electricity/gas price volatility [22]	Reduction in actual cost savings	Hedges; Baseline adjustment of fuel costs
Financial risk (if third party financing is required)	Payment default	Energy saving is not achieved as expected	Inability to service loan and possible termination by banks	Guarantee on energy saving; Performance bond
Project design risk	Insufficient information on facility	Incomplete and poor quality of system operating data [23]	Inaccurate energy baseline; Inaccurate calculation of energy saving	Due diligence; Guided site visit
	Inappropriate design	Improper design and design fault [10]	Shortfall in energy savings	Careful design; design reviews
Installation risk	Completion delay	Adverse weather; shortage of labor; delay in project approvals	Delay in commencement of energy savings	Extension of time clauses
Technology risk	Poor system/Equipment performance	Design deficiency	Reduction in actual energy savings	Careful design; Acceptance tests
	Wrong equipment sizing	Improper equipment sizing [10]	Equipment frequently operating at part- load condition, resulting in reduction of energy savings	Careful design; Acceptance tests
Operational risk	Degradation of equipment	Faster rate of equipment degradation due to poor maintenance [9]	Consuming more energy to achieve the same performance, resulting in reduction of energy savings	Monitoring and diagnostics
	Faulty operation	Improper system operation (e.g. system is often operating at part load condition)	Reduction in actual energy savings	Operation staff training; Provision of system operational procedure guidelines
	Frequent breakdowns	Improper or lack of maintenance [9]	Reduction in profits of ESCO and disturbance to host	Planned maintenance
	Unexpected consumption pattern	Changes in baseline conditions, such as weather, operating hours, load on system conditions [15]	Change in measured energy savings	Proper contract drafting, especially in considering baseline adjustment factors; Follow established M&V guideline
Measurement & Verification risk	Poor data quality	Low resolution of operating data; missing data [23]	Increase in uncertainty on energy saving calculation	Prior agreement on the expected quality of data; Carry out investment grade energy audit
	Modeling errors	Incorrect assumptions on technical aspects [9,24]	The model might be invalid for estimating the baseline energy use after retrofitting, leading to disputes over actual energy savings	Prior agreement on the use of modeling method & assumption
	Inconsistency of data	Improper M&V design (e.g. miss out recording factors which significantly affect energy use) [25]	Dispute over actual energy savings	Proper M&V plan design
	Imprecise/inaccurate metering	Measurement error [26]	Increase in uncertainty in energy saving calculation	Regular calibration; Sub-metering

on the energy savings for the proposed ECMs. With the latter, the ESCO or the host may obtain a loan from a third party financial institution. To ensure the repayment ability, the financial institution may require the ESCO's guarantee on the achievable energy savings (since the ESCO will compensate the loss when there is a shortfall of the guaranteed savings) or some forms of financial security from the borrower.

2.3.3. *Project design risks*

An accurate estimation of energy saving of proposed ECMs is critical to the success of EPC projects. Apart from a proper engineering design [10], the availability of building operating data, which is used to predict energy performance for the newly installed ECMs, is important for the ESCO to evaluate the project risk of expected energy savings [28]. Uncertainties in estimating energy savings will become larger when the quality of system operating data is poor [23]. In practice, before both parties commit themselves to an EPC contract, the ESCO will carry out a detailed energy audit to evaluate the room for saving and the feasibility of proposed ECMs in achieving it.

2.3.4. Installation risks

EPC projects often involve the removal of existing equipment and installation of new ECMs in buildings in use. The removal and installation work are only allowed in specific hours to minimize the disruption to occupants [10]. As such, a project delay may occur, resulting in a delay in materializing the actual energy savings. In practice, the responsibility for such a saving shortfall depends on who causes the delay.

2.3.5. Technology risks

Technology risks mean that the equipment performance and lifetime variations are caused by inaccurate sizing, improper system selection, as well as unexpected deterioration [9,10]. In general, the ESCO fully bears any technology risks during the contract period. These risks can be limited if proper system design, equipment selection and regular maintenance are performed. In some cases, the installation of additional ECMs is allowed during the post-retrofit period in case a shortfall in savings occurs [27]. This provision enables the ESCO to improve the system energy performance and achieve the expected energy savings at its own cost.

2.3.6. Operational risks

Operational risks mean variations in energy savings attributed to changes in the prescribed operation schedule and control strategy of the newly installed equipment [20]. For example, tenants' complaints on noise and air quality may cause a change in the prescribed schedule of system operation, leading to the extension or reduction of operating time, hence affecting the actual energy savings. These operational risks also affect the prescribed adjustment mechanism and cast doubts as to whether it fairly reflects the actual changes in energy savings. In practice, the contracting parties often negotiate on the allocation of operational risks. In most EPC contracts, the ESCO would not be liable to shortfall in savings when the host does not operate the system in accordance with the agreed control strategy and procedures [27].

Other associated risks such as uncertainties in weather and occupancy conditions would also affect the actual energy savings [15]. Although an adjustment mechanism is usually incorporated in EPC contracts to address the impact arising from changes in baseline, it is rather difficult to determine these impacts, resulting in uncertainties in actual savings.

2.3.7. Measurement & verification risks

M&V risks include modeling errors, poor data quality for M&V works, as well as measuring imprecision [10,23,24]. These risks are all intrinsic, and both parties should equally bear them. These risks can be better managed by model validation, proper metering, and implementation of recommended M&V plans.

3. Methods

3.1. Questionnaire survey

Two empirical questionnaire surveys were undertaken in Hong Kong in 2013 to collect first-hand data on the ESCOs' and hosts' views toward the use of EPC. For the hosts' questionnaire survey, it comprises two parts. The first part captured the basic profile of respondents and the corresponding buildings. The respondents were asked to provide their roles and sectors of organization, as well as the type and age of buildings that the respondents own/manage/occupy. The second part solicited rankings regarding the hosts' concerns on the use of EPC. The list of possible concerns was extracted from literature review as presented in the above section. For the ESCOs' questionnaire survey, it consists of three parts. The first part was about the respondents' organizational profiles. The second part focuses on the ESCOs' experience on EPC projects, and the respondents were requested to answer key issues in EPC projects such as allocation of ownership of equipment, payment schedules, EPC contracts and M&V methods for ascertaining energy savings. The third part consisted of ranking questions on risk perception inherent in EPC projects, the hosts' concerns on the use of EPC from the encounters of ESCOs and the practicality of measures to enhance the adoption of EPC. A five-point Likert scale, where 1 denotes "least important" and 5 denotes "most important", was used to analyze the relative importance of the above issues. A pilot study was carried out on a small sample of respondents to ensure the readability of those questionnaires before full distribution.

The target respondents of the questionnaire survey on hosts include local building owners, facility managers and occupants from different sectors (public, quasi-public and private sector). As there are over 40,000 buildings in Hong Kong [29], the surveyed buildings are only limited to commercial buildings, hotels, hospitals, and universities, where the energy use in the common areas accounts for a relatively high proportion of the total energy consumption. Other types of buildings, such as residential buildings, were not targeted at in this study due to the limited amount of achievable energy savings and nature of multi-ownership.

Since all the hotels, hospitals and universities in Hong Kong have to be registered through relevant licensing authorities, the sampling frames of those buildings were developed based on the corresponding registration lists, such as the list of licensed hotels, list of registered hospitals and list of higher education institutions [30–32]. For commercial buildings, the sampling frame was developed based on the database of private buildings in Hong Kong as provided by the Home Affairs Department [29], and a screening of this database was conducted to exclude non-commercial buildings and prevent sample duplications (e.g. the same property with different phases) and incomplete data (e.g. without information of building management companies). Hence, the total number of those buildings was trimmed down from over 5000 to 1872. In order to make this survey manageable, a clustered sampling technique was used in the sampling frame of commercial buildings in accordance with its building location (18 districts). Finally, a total of 885 survey questionnaires were sent to the local building owners, facility managers and occupants, along with a cover letter and a pre-paid self-addressed return envelope. A total of 168 valid questionnaires were returned, representing a response rate of 18.9%.

Since no ESCO accreditation scheme has been set up for the recognition of local energy retrofitting contractors in Hong Kong, the sampling frame was developed based on the member lists of two relevant associations, namely, the Hong Kong Association of Energy Services Companies (HAESCO) and the Hong Kong Federation of Electrical and Mechanical Contractors Limited (HKFEMC) [33,34]. The ESCOs being targeted in this study were those which have capability of implementing turnkey EE projects. Due to listing duplication and the irrelevant nature of some companies (e.g. fire service installation contractors), the targeted ESCOs in this sampling frame were trimmed down from an original number of 178 to 137.

Subsequently, the questionnaire set, comprising a cover letter, a blank questionnaire, and a pre-paid self-addressed return envelope, was sent to 137 target respondents at the managerial level of ESCOs. To increase the response rate and hence the representation of the sample, the assistance of the HAESCO in Hong Kong was sought in approaching their members. Followed up with reminders, 34 valid replies were returned, representing a response rate of

Table 2
Profiles of the host respondents in Hong Kong.

Category	Statistic (%)
Your role	
Facilities Management Staff	61.9%
Tenant	10.7%
Landlord	8.9%
Member of Owner's Corporation	7.7%
Occupier (government department in public buildings)	4.8%
Unit Property Owner	3.6%
Occupier (private organization or NGO using public building)	2.4%
	100%
Type of building	
Industrial	27.4%
Office	19.5%
Residential	15.7%
Shop	10.5%
Hotel	6.5%
Hospital	6.0%
Eating Place	4.8%
Aged People Accommodation	4.0%
Educational	3.2%
Recreational	2.4%
	100%
Sector	
Private	79.2%
Public	11.9%
Quasi Public	6.5%
NGO	2.4%
	100%
Building age	
Less5	12.6%
5–10	7.4%
11–15	10.5%
16–20	17.9%
Over20	51.6%
	100%

Sample size: 168 for the host respondents.

Table 3
Profiles of the ESCO respondents in Hong Kong.

Category	Statistic (%)
Work experience	
Below 5 years	11.7%
6–10 years	8.8%
11–15 years	5.9%
16–20 years	11.8%
Over 20 years	61.8%
	100%
Years of the respondent's department	
Below 5 years	23.5%
6–10 years	20.6%
11–15 years	2.9%
16–20 years	11.8%
Over 20 years	41.2%
	100%
Staff number	
Below 25 staff	29.4%
26–50 staff	20.6%
51–100 staff	14.7%
Over 150 staff	35.3%
	100%
EPC experience	
With EPC experience	35.3%
Understand, but no real experience	50.0%
Not understand EPC and no EPC experience	14.7%
	100%
How many EPC project have you been involved with	
1	8.3%
2	33.3%
3	0%
4	25.1%
Above 4	33.3%
	100%

Sample size: 34 for the ESCO respondents.

24.8%. Tables 2 and 3 summarizes the profile of the host and ESCO respondents in Hong Kong respectively.

3.2. Semi-structured interviews

Twenty-one semi-structured interviews were carried out with key representatives from the public and private sectors in Hong Kong to supplement the questionnaire survey. The techniques of open and neutral questioning were used in the interviews [35], and prior ethical clearance was granted by the university. The interview questions were sent to the interviewees in advance. During the interviews, the interviewees were asked the common set of questions, focusing on the existing local EPC market, risk perception, project financing, possible measures to enhance the use of EPC, etc. The interviewees comprised ESCOs' experts, association representatives, building owners and financers in both public and private sectors in Hong Kong, and they also represent "organizational experts" or "key informants" working at key and responsible positions in the EPC market. All interviews were conducted by two researchers between November of 2013 and July of 2014 with an average duration of 1 h each. To ensure validity of interview results, all interview transcripts were sent to the interviewees for confirmation. A profile of the interviewees is shown in Table 4.

4. Results

4.1. Profile of respondents – hosts

Table 2 presents the profile of the host respondents in Hong Kong. Among the host respondents, facilities management staff comprises 61.9%. Other respondents are tenants (10.7%), landlords (8.9%), members of owners' corporation (7.7%), public occupiers using public buildings (4.8%), unit property owners (3.6%) and private occupiers using public buildings (2.4%). In addition, 79.2% of respondents come from the private sector, while 11.9% of them are from the public sector. Quasi-Public and NGO comprise 6.5% and 2.4% of the total respondents respectively. In terms of the building types, industrial buildings, office buildings and residential buildings represented 27.4%, 19.5% and 15.7% respectively. Other building types are shown in Table 2. Furthermore, over half of their buildings are over 20 years' old.

4.2. Profile of respondents – ESCOs

Table 3 shows the profile of the ESCO respondents in Hong Kong. Respondents are practitioners of different building energy retrofitting firms, including electrical and mechanical (E&M) companies, equipment manufacturers, power supply companies, etc. Regarding respondents' work experiences, 61.8% of the respondents have been working over 20 years in the related field, 17.7% of respondents have work experience between 11 and 20 years, and 20.5% of respondents have worked for less than 10 years. The number of staff in the respondents' company varied considerably: 29.4% of respondents' firms have less than 25 staff, 35.3% have between 26 and 100 staff, and 35.3% have over 150 staff. Hence, about 70% of the firms are medium to large in size.

Since the EPC market is still at a developing stage in Hong Kong, only 35.3% of respondents have hand-on experience in EPC projects. 50% of respondents understand the concept of EPC with no hand-on experience, and some of them were involved in the stage of energy audit and project negotiation, but the project was not implemented eventually. Among the respondents with EPC experience, 58.4% of respondents were involved with 4 or more EPC projects, and 41.6% of them were involved with 1–2 projects.

Table 4
Profile of interviewees.

ID	Sector	Position of interviewee	Nature of organization
1	Public	Manager	A building owner (University)
2	Public	Associate Director	A building owner (University)
3	Public	Senior Manager	A building owner (Hospital)
4	Public	General Manager	A building owner (Hospital)
5	Public	Senior Engineer	A public sector works department
6	Public	Retired Chief Engineer	A public sector works department
7	Public	Senior Manager	A public hospital administration
8	Public	Senior Consultant	A trade council
9	Private	General Manager	A building owner
10	Private	Technical Services Manager	A building owner
11	Private	Group Engineering Manager	A building owner
12	Private	Managing Director	A consultant
13	Private	General Manager	An ESCO
14	Private	Senior Manager	An ESCO
15	Private	Director	An ESCO
16	Private	Project Manager	An ESCO
17	Private	Sale Director	An ESCO
18	Private	Account Manager	An ESCO
19	Private	Manager	A bank
20	Private	Estate Manager	A FM company
21	NGO	Chairman	An association of energy services companies

4.3. Analysis of survey results

4.3.1. Mean score ranking technique

The "mean score" (MS) method was used to establish the relative importance of perceived risks inherent in EPC projects, the hosts' concerns on the use of EPC and the practicality of measures to enhance the use of EPC. The five-point Likert scale described previously was used to calculate the MS of each factor, and the answers were ranked in descending order. The results of the relative importance as reflected by the MS are shown in Tables 8, 9 and 11.

4.3.2. Cronbach's alpha test

The Cronbach alpha test was adopted to measure the internal consistency and reliability of the questionnaires. Nunnally [36] indicated that at least 0.60 is considered as an acceptable alpha value for non-validated instrument. As shown in Table 5, the Cronbach's alpha values for these questionnaires were satisfactory for three sets of questions (the alpha values of the perceived risks, the hosts' concerns on EPC and the practicality of measures to enhance the use of EPC were 0.864, 0.763 (hosts), 0.674 (ESCOs) and 0.802 respectively).

4.3.3. Kendall's W test

The Kendall's coefficient of concordance (W) was computed to assess the level of agreement and consistency within a particular survey group. The Kendall's W coefficient may range from 0 (complete disagreement) to 1 (total agreement). If the total number of sub-questions in any section was larger than 7, the Chi-square test was adopted for acceptance or rejection of a hypothesis [37]. It is concluded that the respondents' sets of ranking are related to each other within a survey group when the Chi-square value is greater than the critical value at a particular level of significance (1% of significance being adopted in this study). Table 6 shows the Kendall's W coefficients with the ESCO and host survey groups, indicating coherence of responses with the respective groups.

4.3.4. Mann–Whitney U test

The Mann–Whitney U test is a non-parametric test which is often used to test whether two independent groups of respondents observed have the same rank distributions. It is concluded that the two groups of observations are significantly different from each other when the significance level is less than 5%. Only the similar question of hosts' concerns on the use of EPC by two different respondent groups of hosts and ESCOs was subject to the Mann–Whitney U test, and the results are shown in Table 10.

5. Discussion

5.1. ESCOs' views on EPC projects in practice

Table 7 summarizes the answers by ESCOs on the arrangement of EPC projects, and each topic is discussed as follows:

5.1.1. Mode of EPC project

As discussed in Section 2.1, guaranteed savings and shared savings are the two most common models in EPC projects. The key difference between them mainly lies in the allocation of financial and performance risks. Table 7 shows that both models are almost equally adopted in EPC projects (46.2% for the shared saving model; 38.5% for the guaranteed model), implying that each model has a distinctively suitable set of circumstances for its use. The ESCO interviewees opined that their hosts expect higher energy savings in the guaranteed model as the hosts absorb the financial risk, while in the shared saving model the ESCOs tend to mitigate credit risk by controlling project investment and using conservative ECMs, rather than a comprehensive energy improvement solution. Previous studies found that the selection of EPC models depend on a number of factors, including maturity of local financial market, creditability of contracting parties, expected energy savings, as well as confidence on energy efficiency technologies [3]. Okay and Akman [38] indicated that the shared saving model is preferred in developing countries because the host has no financial risk, with the benefit that the debt does not appear on the host's balance sheet. Larsen et al. [39] discussed that the guaranteed saving model is more preferable in the public sector in the U.S. due to the greater certainty of savings since the ESCO fully bears the performance risk of proposed ECMs.

5.1.2. Operation and maintenance

Piette et al. [40] discussed the importance of proper system operation and maintenance (O&M) in achieving energy savings. Hence, the arrangement of O&M work is crucial for the ESCO to ensure that the newly installed systems operate at design conditions. Table 7 shows that in most EPC projects (76.5%), the ESCO is only responsible for maintenance work, whilst the system operation is handled by either the host or property management

Table 5
Results of Cronbach's alpha test.

Section in questionnaire	Cronbach's alpha	
	Host	ESCO
Importance of risk factors relevant to EPC as perceived by ESCO	0.864	NA
Hosts' concern on EPC (Hosts' survey) andReasons for hosts not considering EPC (ESCOs' survey)	0.763	0.674
Practicality of measures to enhance the adoption of EPC in Hong Kong	0.802	NA

Table 6
Results of Kendall's *W* and Chi-square test.

	Importance of risk factors relevant to EPC as perceived by ESCO	Hosts' concern on EPC (Hosts' survey) and Reasons for hosts not considering EPC (ESCOs' survey)		Practicality of measures to enhance the adoption of EPC in Hong Kong
Role	ESCO	Host	ESCO	ESCO
N	31	129	31	32
Kendall's *W*	0.087	0.109	0.181	0.107
Chi-square	35.17	112.02	44.77	48.03
Degree of freedom	13	8	8	14
Chi-square critical value (at 1%)	27.69	15.51	15.51	29.14
Asymptotic significance	<0.001	<0.001	<0.001	<0.001
H_0	*R*	*R*	*R*	*R*

H_0 = respondents' rankings are independent of each other within each group.
Reject H_0 if the actual Chi-square value is larger than the critical value of Chi-square.

company. This implies that the hosts tend to retain the control of system operation to ensure a good balance of occupant comfort and energy savings, or they have existing staff for operation. In order to protect ESCO's interest in relation to proper system operation and hence ensure energy savings, most standard forms of contract stipulate that the host shall comply with proper operational procedures [16]. When shortfall in savings is due to deficiency of system operation arranged by the host, the ESCO will not be liable to the host for compensation of such shortfall.

5.1.3. Ownership of equipment

A majority of the respondents (75%) indicate that the ownership of equipment is vested in the host, instead of the ESCO, even when the upfront cost for project implementation is fully paid by the ESCO. A possible explanation for this dominance is related to the host's bargaining power. Most interviewees pointed out that hosts are rather conservative toward the use of EPC for EE projects in the immature EPC market. In order to attract potential customers, ESCOs with a strong financial capability would offer to the host the sole ownership of equipment. The ESCO interviewees also mentioned that even though the ESCO may retain equipment ownership, the risk of non-payment would not be considerably reduced because the resale value is rather limited when the equipment is detached from the host's building, let alone this being an almost impossible mission. Instead, the ESCO would prefer to protect its own interest by inserting a contract clause to the effect that the ESCO would have to compensate for the remaining value of equipment in the event of contract termination. The selection of well-established customers, for example, those with a strong cash flow, is another way to mitigate the risk of non-payment.

5.1.4. Energy baseline establishment

Several scholars discussed that an accurate establishment of energy use baseline is vital to avoid dispute over actual energy savings [4]. The criteria to develop a well-established baseline include the duration of baseline measurement period, completeness, quality and resolution of operating data [26]. In practice, the direct use of building management system (BMS) data provided by the host for baseline development is rather uncommon. A majority of respondents (86.9%) claimed that short/long-term measurement and use of electricity bills are the primary ways for the ESCO to analyze the energy use in existing systems, implying that the ESCO is not confident enough in using the operating data provided by the host. Interviewees explained that incomplete and poor quality operating data often prevail in existing buildings. Despite the fact that the direct measurement by the ESCO increases the costs of project implementation and duration, it may reduce the risk of uncertainty in baseline development, and hence minimize the uncertainty in ascertaining the correct level of energy savings.

5.1.5. Payment

The amount of payment in EPC projects is tied to actual energy savings being achieved by the ESCO during the post retrofit period. Since energy consumption in weather-dependent systems, such as a central air-conditioning system, varies significantly throughout a year, the selection of a suitable payment arrangement is important for the ESCO to maintain a stable cash flow of project. Table 7 shows that the respondents tend to use fixed payment schedules with deduction of performance shortfall during contract period. It means that the ESCO receives the fixed amount of payment from the host when the actual savings are reckoned as being equal to/more than the guaranteed one in each M&V period, which could be a month, quarter or year. Interviewees mentioned that the risk of payment default is much higher when the amount of payment is completely linked to the measured savings. This is because energy performance is rather difficult to measure accurately and equitably [41], it is not uncommon for the host to dispute the amount of energy savings being achieved by the ESCO, especially when the building operation and occupancy level vary considerably from time to time.

5.1.6. Energy saving estimation method

An accurate estimation of expected energy saving is essential to mitigate the performance risk in EPC projects. The common approach of energy saving estimation includes the simplified engineering method, regression analysis and building energy simulation [28]. The main differences among them lies in the accuracy of model estimation, requirement on data quality and completeness, cost of model development as well as the ability of explanation in pre-set condition change. Table 7 shows that respondents tend to use the simplified engineering method (36.4%) and regression analysis (45.5%) in estimating expected energy savings in practice. One reason is that the simplified engineering method provides a quick

Table 7
Breakdown of responses for questions to ESCOs on the arrangement of EPC projects.

Mode of EPC		
Which type(s) of EPC projects have you been involved with?		Percent
Choice	(a) We finance, design, supply, install equipment for host in return for a share of energy cost saving	46.2%
	(b) We design, supply, install equipment with host or 3rd party financing and our guarantee on energy saving	38.5%
	(c) We provide consultancy service only for clients	15.3%
		100%
Operation and maintenance		
Do you maintain/operate the equipment for the EPC projects within the contract periods?		Percent
Choice	(a) Yes, we carry out maintenance and operation	5.9%
	(b) We carry out maintenance only, with operation by host's own staff	47.1%
	(c) We carry out maintenance only, with operation by property management companies	29.4%
	(d) We carry out operation only, with maintenance by others	0%
	(e) Host carries out their own maintenance and operation, with our advice and training	17.6%
		100%
Ownership of equipment		
How about ownership of the equipment installed under the EPC projects?		Percent
Choice	(a) Ownership by host	75.0%
	(b) Ownership by our organization, with leasing to host within the contract period.	25.0%
	(c) Ownership by financier until loan is paid off	0%
		100%
Energy baseline establishment		
Which method have you used to develop the baseline of energy consumption on EPC projects?		Percent
Choice	(a) Based on electricity bills	39.1%
	(b) Based on short-term measurements (e.g. logging data for less than six months)	21.7%
	(c) Based on long-term measurements (e.g. logging data for six months or longer)	26.1%
	(d) Based on BMS data provided by host or host's FM Company	13.1%
	(e) Based on energy audit report carried out by 3rd party	0%
		100%
Payment		
In your EPC contracts, what are the bases of the payment terms?		Percent
Choice	(a) Fixed payment schedule, with deduction for performance shortfall at interim periods	61.5%
	(b) Fixed payment schedule, with deduction for performance shortfall at contract end	15.4%
	(c) Strictly based on measured cost saving	23.1%
		100%
Energy saving estimation method		
Which method(s) have you adopted in estimating energy saving?		Percent
Choice	(a) Simplified engineering method (e.g. power rating x operating hours for lighting retrofit)	36.4%
	(b) Regression analysis model	45.5%
	(c) Building energy simulation program (e.g. EnergyPlus)	18.1%
		100%
EPC contract documents		
Which basis have you encountered in preparing an EPC contract?		Percent
Choice	(a) Contract written in-house and agreed with the client	73.4%
	(b) Modified from a standard construction contract	0%
	(c) Modified from a standard E&M contract	13.3%
	(d) Direct use of an overseas standard form of EPC contract (e.g. ESPC in the U.S., EPC in Canada, GESP in Singapore)	0%
	(e) Modified from an overseas standard form of EPC contract (same examples as above)	13.3%
		100%
EPC financial evaluation		
Which method(s) have you used for EPC project financial evaluation?		Percent
Choice	(a) Net Present Worth	24.0%
	(b) Internal Rate of Return (IRR)	20.0%
	(c) Benefit Cost Ratio	12.0%
	(d) Payback Period	44.0%
		100%

estimation with acceptable confidence, especially for non-weather dependent retrofitting such as lighting retrofit, while regression analysis is a statistical approach for estimating the relationships among variables, and this method is recommended by a variety of M&V guidelines for prediction and forecasting [23]. However, the main drawback of those methods is a lack of explanation power as only several independent variables are considered in the model for baseline adjustment, and in reality variations in other energy influential factors such as weather conditions and building use pattern often occur, leading to uncertainty in using these models. The ESCO interviewees opined that although the use of building energy simulation program enables the ESCO to better understand the implication of change in energy use when the baseline conditions vary accordingly, in practice it is costly and time-consuming to develop such a simulation model.

5.1.7. EPC contract documents

Although several standard forms of EPC contracts have been developed in some countries (e.g. Standard Energy Performance Contract in Australia, BOMA Energy Services Performance Contract in the U.S.), most respondents (73.4%) tend to use an in-house written EPC contract, instead of a modified overseas standard form of EPC contract or a modified E&M contract. According to the ESCO interviewees, this is due to the fact that most hosts are unfamiliar with contract terms in those overseas standard documents, raising a question of fairness in risk allocation in those contracts. The interviewees also mentioned that most of the in-house written EPC contracts are rather simple. Several key issues such as significant changes in building operation during contract period and termination of contract might not be fully addressed.

5.1.8. EPC financial evaluation

Several studies revealed that Net Present Value (NPV), Internal Rate of Return (IRR) and Payback (PB) analysis are the most popular tools for capital budgeting of EE projects across the world [14]. Table 7 shows that PB analysis is the most commonly used financial instrument for evaluating EPC projects. This is because PB analysis is an effective tool for the ESCO to limit performance risks by selecting a project with a short payback period. However, some criticisms on the use of PB analysis are that it would screen out most of the profitable EE projects with long payback periods. The use of NPV approach is an alternative to compensate the deficiency of PB analysis on investment decision. It can show that an EE project generates net financial benefits when the sum of discounted savings is greater than the total investment costs. However, the interviewees mentioned that PB analysis is still a primary tool in investment decision making due to its straightforward principle.

5.2. Risks and concerns on EPC projects

Table 8 shows the relative importance of risk factors relevant to EPC projects. “Payment default of host after installation” is perceived as the most important risk factor amongst 14 factors (mean score: 3.88). As for the EPC projects for which the ESCO pays the upfront capital for project implementation, the regular payment to the ESCO is crucial to maintain a positive cash flow. Yik and Lee [41] highlighted the difficulties in measuring energy performance accurately and equitably, and therefore the actual energy savings may be disputable, especially in circumstances where the energy baseline and adjustment mechanism are not well established at the pre-retrofit stage. Apart from possible dispute on actual savings, host’s bankruptcy and dismissal of a building management body are also possible reasons for non-payment. Some ESCO interviewees opined that the change of top official in companies, such as Chief Financial Officer (CFO), might also lead to payment default or reduction in scheduled payments as they might raise question about the actual energy savings being achieved by the ESCO.

“Not sure if baseline measurement can be correctly established” was ranked as the second with a mean score of 3.74. This is in line with previous research findings that difficulties were encountered in establishing a reliable energy consumption baseline in existing buildings [41,42]. Since there is a weak awareness for keeping proper record of building operating data, as experienced in the previous decades, incomplete and poor record of building operating data (e.g. low resolution, long interval and missing data) are often encountered when the ESCO starts the energy audit for baseline establishment [40]. In addition, the lack of calibration of temperature sensors and measurement devices for a long period of time is also attributable to the ESCOs’ lack of confidence on the validity of the recorded data. Without the reliable past building operating data, it is difficult for both parties to develop the agreed energy use baseline for ascertaining energy savings, and it would be even more arguable when baseline adjustment is proposed for incorporating changes in building operation in future. As consistent with previous finding in this study, direct measurement is often carried out by the ESCO to mitigate the risk of uncertainties in developing energy use baseline.

“Costs of installation increase” was reckoned as the third important risk with a mean score of 3.62. Since EPC projects are often arranged on lump-sum basis, the ESCO fully bears the risks associated with increases in labor costs, material costs and equipment costs. Usually, no cost adjustment mechanism is put in the EPC projects. When these costs rise dramatically during the installation period, the ESCO would suffer from increase in project implementation cost, and thereby affect the profit achievable.

Both host and ESCO respondents were asked to rank the importance of a list of concerns about the use of EPC. In the ESCOs’ questionnaire, it was designed such that they answered this question from their experience in project negotiation with customers, so that comparison can be made with the hosts. The results of hosts’ concerns on the use of EPC are listed in Table 9.

“Long payback period” was viewed as the top concern among 9 others by both the hosts themselves and ESCOs reflecting the hosts’ views (mean score: 4.04 for hosts; 3.82 for ESCOs). This is consistent with literature findings that a short payback period is preferable as it is an effective way to mitigate project risk [14,43]. During contract period, certain contractual obligations in relation to an alteration of building premises are imposed on the host. As the median payback period of EPC projects varies from 2 to 10 years, depending on the type and scale of retrofitting [39], a shorter payback period would enable the host to have more flexibility in changing their building premises and operation to suit future business needs.

“Worry about ESCOs’ guaranteed saving not being achieved, causing problem to third party financing” was viewed as the second top concern from the view of hosts (mean score: 3.76 for hosts). Although the ESCO guarantees the host a certain level of energy savings to ensure the host’s repayment to the third party, the actual energy saving is still uncertain. This is because there are various extrinsic factors, such as change of occupancy and weather conditions, making the project not achieve the expected amount of savings. For examples, due to economic downturn, the occupancy rate of a hotel drops significantly, resulting in a significant reduction in the actual energy savings, and in such case, the ESCO is not responsible for non-performance of guaranteed savings. Therefore, the host is not risk-free despite the ESCO’s guarantee on savings.

“Worry about its complexities” was also perceived as one of the top three concerns in implementing EPC projects from both hosts’ and ESCOs’ views (mean score: 3.70 for hosts; 4.29 for ESCOs). As compared with the traditional EE projects, EPC projects entail a larger work scope, including the arrangement of project financing, establishment of energy use baseline, M&V and demarcation

Table 8
Mean score and rankings of the relative importance of risk factors relevant to EPC as perceived by ESCOs.

Please rank the relative importance of risk factors relevant to EPC as perceived by ESCO		ESCO		
		Mean	SD	Rank
1	Not sure if expected performance can be achieved (e.g. due to change in baseline condition such as weather, occupancy, room usage etc.)	3.47	0.961	5
2	Not sure if baseline measurement can be correctly established (e.g. due to incomplete and poor quality of data obtained from energy audit)	3.74	0.864	**2**
3	Not sure if energy saving determination method is accurate (e.g. system modeling error)	3.41	0.925	6
4	Not sure if measurement after installation is accurate	3.59	0.988	4
5	Not sure if host would change use pattern without informing ESCO	3.45	0.869	7
6	Not sure if host would operate plant as advised during contract period	3.39	0.899	8
7	Not sure if actual maintenance cost is smaller than the expected budget	3.33	0.924	9
8	Not sure if actual M&V cost is smaller than the expected budget	3.24	0.987	10
9	New installed equipment perform poorly due to improper design (e.g. oversizing)	3.00	0.985	13
10	New equipment deteriorate much faster than expected	3.24	1.046	11
11	Payment default of host after installation	3.88	0.740	**1**
12	Costs of installation increase (e.g. exchange rate, equipment cost, labor cost)	3.62	0.954	**3**
13	Interest rate fluctuation (if the 3rd party finances the project)	3.03	1.045	12
14	Energy price fluctuation	3.00	1.206	14

Numbers in bold indicate the top three ranking.
Sample size: 34 ESCO respondents.

Table 9
Mean score and rankings of the reasons for hosts not considering EPC.

Hosts' concern on EPC (Hosts' survey) and Reasons for hosts not considering EPC (ESCOs' survey)		Host			ESCO		
		Mean	SD	Rank	Mean	SD	Rank
1	Lack of familiarity with EPC	1.08	3.58	6	0.88	4.12	**2**
2	Worry about its complexities (e.g. procedures, legal issues)	1.07	3.70	**3**	0.80	4.29	**1**
3	Not convinced that EPC can achieve higher saving than design-bid-build	1.09	3.02	9	0.83	3.45	6
4	Worry about measurement & verification inaccuracies (assuming no fraud)	0.97	3.48	7	0.86	3.59	4
5	Not convinced that it is cost effective	1.02	3.26	8	0.99	3.41	7
6	Worry about disruption to their normal business operation or use of property	1.12	3.67	4	1.08	3.41	8
7	Worry about ESCOs' guaranteed saving not being achieved, causing problem to 3rd party financing	0.99	3.76	**2**	0.93	3.50	5
8	Worry about integrity of ESCOs	1.05	3.63	5	0.94	3.27	9
9	Long payback period	0.90	4.04	**1**	1.11	3.82	**3**

Numbers in bold indicate the top three ranking.
Sample size: 168 host respondents; 34 ESCO respondents.

of O&M responsibilities. In addition, the contract drafting introduces extra complexities since every EPC project is unique in terms of its patterns of building operation, scope of retrofit and methods of baseline adjustment. Considerable efforts are required for both contracting parties to negotiate the risks and responsibilities which each party bears in an EPC project.

Apart from the above top three concerns on the use of EPC, it is worth noting that there are several other concerns which are significantly different between the views of hosts and ESCOs, as revealed by the Mann–Whitney *U* test. Table 10 shows that the hosts and ESCOs held a divergent view toward "lack of familiarity with EPC" and "Worry about its complexities". The ESCO respondents thought that the above concerns are the most important concerns of the hosts in considering EPC, whilst hosts were less expressive about these inadequacies. "Worry about integrity of ESCOs" is another concern that is significantly different between the views of hosts and ESCOs. The result shows that the hosts worry more about the integrity of ESCOs in implementing EPC projects, as it was ranked at fifth (mean score: 3.63), while in the view of ESCOs, this worry is of the least concern among 9 factors (mean score: 3.27). This difference is explainable for hosts who normally have no engineering expertise to ensure measurement accuracy and the use of a correct method in calculating energy savings.

5.3. *Practicality of measures to enhance the use of EPC*

Whilst EPC has been used successfully in achieving energy savings, there are various barriers in this adoption [4]. As such, different counties developed their own incentive measures in the past decade. Those measures focus on various practical aspects, including the availability of standard EPC contracts, ESCO accreditation, EPC guidelines, joint government-bank back-up of energy saving guarantee, etc. Based on the intensive literature reviews, Table 11 lists possible measures to enhance the use of EPC. The ESCO respondents suggested that "Promote successful examples of EPC projects" was the most practical measure to enhance the wider use of EPC (Mean Score of 4.41). This finding echoes other recommendations that more EPC demonstration projects should be shown to the public for validating the concept of EPC [1]. An EPC project not only involves the design and installation of ECMs, but also provides a number of services to the host, including the ongoing performance monitoring of ECMs, project financing, operation (if required by the host), maintenance and staff training. At the beginning of EPC market development, hosts and industry practitioners might not be fully familiar with the whole life cycle of an EPC project, especially in the pre- and post-retrofit stages, when the accurate baseline establishment and appropriate methods for baseline adjustment

Table 10
Results of Mann–Whitney *U* test.

Section ID	Section in questionnaire	Respondents from hosts vs ESCOs (Asymp. Sig. < 0.05)
Hosts' concern/Likely reasons for hosts NOT considering EPC (as perceived by ESCOs)		
1	Lack of familiarity with EPC	0.008
2	Worry about its complexities (e.g. procedures, legal issues)	0.003
3	Not convinced that EPC can achieve higher saving than conventional approach	0.017
8	Worry about integrity issues of ESCOs	0.048

Table 11
Mean score and rankings of the practicality of measures to enhance the adoption of EPC in Hong Kong.

Possible measures		ESCO		
		Mean	SD	Rank
1	Promote successful examples of EPC projects	4.41	0.821	**1**
2	Public sector takes a leading role in adopting EPC	3.70	0.918	10
3	Modification of government procurement practices to facilitate the use of EPC contracts	4.00	0.739	**2**
4	Government backs up a portion of ESCOs' guarantee to lending banks (as in Singapore)	3.97	1.029	**3**
5	Promote the value for money of EPC amongst building owners	3.91	0.793	4
6	Standard M & V procedures for major types of energy retrofitting	3.56	0.927	13
7	A suit of standard EPC contracts for use with major types of energy retrofitting	3.71	1.060	8
8	Further strengthen the requirement of Building Energy Code and efficiency standards	3.44	.991	14
9	A joint fund by gov't, investment banks & oil companies to guarantee majority of financings obtained by ESCOs, with suppliers, equipment leasers, ESCOs and banks bearing rest of payment default risk by owners.	3.85	0.925	5
10	Establishment of awards for ESCOs based on transparent criteria	3.85	0.755	5
11	Accreditation and maintenance of a register of ESCOs (as in Singapore)	3.85	1.048	5
12	Development of new technologies and energy efficient products	3.71	0.906	8
13	Publication of clear guidelines on EPC procedures	3.64	0.822	11
14	Use of a standard consultancy agreement for energy audit	3.45	1.121	15
15	Insurance against energy efficiency shortfall (as in the US)	3.59	3.59	12

Numbers in bold indicate the top three ranking.
Sample size: 34 ESCO respondents.

are crucial to the success of EPC projects. Together with project financing, these are the unique features in EPC projects, causing complexities of project implementation. With the promotion of successful EPC projects from the government or trade associations, a clear picture of its benefits would be effectively delivered to different parties, including potential customers, ESCOs, and financial institutions, in relation to the possible application of energy efficient technologies through EPC.

"Modification of government procurement practices to facilitate the use of EPC contracts" was viewed as the second most practical measure to enhance the use of EPC (mean score: 4.00). Since one of the merits of EPC projects is to allow flexibilities for the interested ESCOs to propose different ECMs, it is often the case that the tender proposals from different ESCOs vary significantly in key evaluation aspects, such as the upfront capital costs, estimated savings, as well as payback period. However, due to inflexibilities in the public procurement process and internal accounting requirements, such as demarcation of capital and recurrent expenditures, the current tender evaluation scheme in the public procurement process might not be conducive for evaluating different ESCOs' retrofit proposals [4]. Several researchers in many countries also recommended the modification of government procurement practices for EPC projects, for example, the use of life cycle cost instead of direct cost comparison for tender evaluation [1,18]. In the U.S., due to the enactment of EPC related legislation, a special procurement procedure for EPC projects was developed to facilitate the use of EPC in the Federal buildings, and this procurement procedure for EPC projects would prioritize over the current Federal Acquisition Regulation (FAR) procurement requirement if there is a conflict [44]. This move opens up the EPC market in the public sector, and despite the onset of severe economic recession, a market growth of about 7% per year between 2007 and 2010 was recorded in the U.S. ESCO industry [39].

"Government backing up a portion of ESCOs' guarantee to lending banks" was perceived as the third most practical measure (mean score: 3.97). This is consistent with other research findings that the active participation of financial institutions is crucial for the development of the EPC market [1,4]. Due to the hesitation of financial institutions on EPC project financing, especially in the immature EPC market, a high interest rate is often charged on private borrowers in order to mitigate the financial risk of lenders, hence discouraging the use of EPC for EE projects. Therefore, it is necessary to build up the financial institutions' confidence and lower transaction costs of project financing. This could be achieved by government backing up a portion of ESCOs' guarantee to lending banks. For example, the Singaporean government has lined up financial institutions to implement the pilot "Building Retrofit Energy Efficiency Financing (BREEF) Scheme". This scheme is mainly targeted at those building owners who have inadequate upfront capital for building retrofits. As the risk of any loan default is shared by the government and banks, the participating financial institutions provide loans up to S$5 million with low interest rate to those hosts for implementing EE projects [7]. This measure provides an opportunity for the related parties, especially financers, to understand the whole framework of EPC projects in practice.

6. Conclusions

The aim of this study is to identify the risks inherent in EPC projects and the factors affecting their allocation, and investigate the hosts' concerns on the use of EPC, as well as explore the practical measures to enhance the wider adoption of EPC. According to the data collected in two separate questionnaire surveys, it was found that "payment default of host after installation", "not sure if baseline measurement can be correctly established", and "costs of installation increase" were the top three key risk factors in EPC projects. The results also indicate that the primary hosts' concerns on EPC projects are associated with the "long payback period", "worry about its complexities" and "worry about ESCOs' guaranteed saving not being achieved, causing problem to third-party financing".

In order to enhance the wider adoption of EPC, different counties developed their own incentive measures in the past decade, including development of a standard EPC contract, ESCO accreditation scheme, EPC guidelines, as well as procurement modification, etc. Comparing the efficacy of those possible measures, the survey results show that "promoting successful examples of EPC projects", "modification of government procurement practices to facilitate the use of EPC contracts", and "government backing up a portion of ESCOs' guarantee to lending banks" are the top three practical measures for better market development in order to achieve higher energy savings. In addition to the survey findings, the effectiveness of those measures can also be reflected through an examination of the EPC market in several countries. For examples, in the U.S., the amendment of procurement procedures and provision of project facilitators provide incentives to the host for undertaking EPC projects in the public sector, ultimately resulting in a market growth of the ESCO industry [39]. In Singapore, due to a positive response on EPC from the ESCO industry, the Singaporean government launched a second phase of the pilot Building Retrofit Energy Efficiency Financing (BREEF) Scheme where the risk of any loan default is shared by the government and banks. It is expected that this pilot scheme will contribute to a higher penetration rate of EPC projects in their local market [7]. Since few studies have focused on risk perception and concerns in EPC projects, this study contributes to the body of knowledge in relation to the improved management of EPC projects.

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