LEE, P., LAM, T. I., & Dzeng, R. J. (2014). Current market development of energy performance contracting–a comparative study between Hong Kong and Taiwan. Journal of Property Investment & Finance, 32(4), 371-395.

Current Market Development of Energy Performance Contracting – A Comparative Study between Hong Kong and Taiwan

Abstract

Purpose – This study is to investigate the current market development of Energy Performance Contracting (EnPC) in Hong Kong and Taiwan, focusing on four key aspects: 1) the potential building energy retrofit as an investment for future savings; 2) the motivations for building owners towards the use of EnPC and; 3) the reasons for building owners not using EnPC, and 4) the different approaches of Hong Kong and Taiwan governments towards the promotion of EnPC.

Design/methodology/approach –A dual-questionnaire survey was conducted both in Hong Kong and Taiwan, where the same set of questionnaire was sent to the key personnel of the Energy Services Companies (ESCOs) in both regions as identified from the latest member lists of representative trade associations, supplement with 11 structured interviews.

Findings – Apart from explainable differences, the results show the top rankings by the respondents of Hong Kong and Taiwan as follows: (A) **"Potential retrofit works"** including lighting replacement with efficient fluorescent and LED lamps and improvement of air-con system. (B) **"EnPC Motivations"** including owners' lack of upfront capital and use of energy savings for other purposes may yield better returns; ESCOs' provision of turnkey services. (C) **"Reasons not considering EnPC"** including worry about its complexities; lack of familiarity with EnPC and long payback periods.
As for promotional efforts for EnPC, the Taiwan government has taken more initiatives to foster its use both technically and financially.

Practical Implications – This study identifies market-related motivators and deterrents as experienced by ESCOs in implementing EnPC projects in two developed Asian economies.

Originality/value – This study provides insightful information for the stakeholders about the latest market development of EnPC in Hong Kong and Taiwan.

Keywords – Energy Performance Contracting, Energy Efficiency Investment, Hong Kong, Taiwan, Incentives, Deterrents

Paper type – Research Paper

1. Introduction:

Although buildings account for 40 percent of world's energy use (World Business for Sustainable Development, 2009), most of the existing buildings are not energy efficient (Lee et al., 2001). This is often ascribed to equipment oversizing, unrealistic design, poor thermal efficiency, use of ageing equipment and technology (Taylor and World Bank., 2008). Through an improvement of building insulation, enhancement of building system and equipment efficiencies, as well as optimization of system operation, a significant reduction of energy use in existing buildings can be achieved. Other factors, such as high energy prices, the impending increases in future energy prices, government incentives and low interest rates, also enhance an awareness of the value of energy efficiency investments in existing buildings (Jackson, 2010).

However, the hesitation of energy efficiency investments in existing buildings is still observed all over the world. Lack of capital costs and technological know-how are often the major barriers to implementing energy efficiency projects. To address this problem, the concept of Energy Performance Contracting (EnPC) was introduced to provide building owners an alternative for enhancement of building energy efficiency in existing buildings. According to the Directive 2006/32/EC, the European Parliament defines EnPC 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" (The European Parliament, 2006). It means that, at the initial stage, energy service companies (ESCOs) guarantee or share the energy cost savings with building owners and implement the retrofit project, including design, installation, construction, measurement and verification (M&V) of savings. Building owners only make a series of payment to ESCOs when the actual energy cost savings are realized. In case of shortfall in savings, ESCOs will compensate the losses incurred by building owners under the contract agreement. Figure 1 illustrates the concept of EnPC model.

The status of development in the EnPC market in the world is relatively diverse. In the U.S., with the strong commitment of the Federal government to enter into the energy savings performance contracts (The U.S. Department of Energy (DOE), 2014a), EnPC has largely been a successful model to improve the energy efficiency (EE) in public/institutional buildings (Larsen et al., 2012). Despite the onset of a severe economic recession, the U.S. ESCO industry still registered a market growth of about 7% per year between 2006 and 2008 (Larsen et al., 2012). In Europe, a strong market growth between 2007 and 2010 was observed in Denmark, Sweden, and Romania as a result of changes towards favorable legislative framework, while a decreasing growth was reported in Austria, Croatia, Norway and the United Kingdom due to difficulties in obtaining finance (Marino et al., 2011). In the Asia-Pacific region, considerable market activities were reported in Australia, Japan and South Korea (Murakoshi and Nakagami, 2009;Kellett and Pullen, 2012). However, criticisms were leveled at the

wider use of this business model due to a lack of standardization of performance contracts as well as measurement and verification (M&V) guidelines, a lack of knowledge and experience among clients, local ESCOs and financial institutions, in addition to the insufficient competitiveness of ESCOs (Bertoldi et al., 2006;Marino et al., 2011;Xu et al., 2011). As a result, the penetration of this model into the private sector is still relatively low (Yik et al., 2001), and to-date the ESCO market is often dominated by the institutional sector due to the perceived low credit risks, strong supporting policy (e.g. Federal Energy Management Program in the U.S.), alongside competent engineering and legal representation from the institutional sectors including education and health care. To further promote EnPC as an effective means to improve building energy efficiency, extensive works and efforts need to be made to overcome the above barriers, such as the development of standard forms of EnPC contacts, promotion of successful projects, development of an International Performance Measurement and Verification Protocol, and the engagement of financial institutions (Energy Valuation Organization, 2012;BOMA, 2014). For example, an EU-Energy Performance Contracting Campaign (EPCC) launched by the European Commission is a crucial step to address key issues such as accounting of public deficit and debt, and helps member states in establishing a legal and financial framework for the EnPC market (European Commission, 2014).

Several researchers revealed the latest market development of EnPC and ESCO activities in the world. Vine (2005) conducted an international survey to estimate the local ESCO activities, identified the major market barriers and provided possible measures for promoting ESCO industry in 41 countries. At the regional level, Marion et al. (2011) carried out a survey of energy service market in 39 European countries, emphasizing on the latest ESCO industry trends, the contributing factors to market development and policy recommendations. Larsen et al. (2012) conducted a survey of the U.S. ESCO industry, focusing on ESCO activities by market segment, project performance, perceived trends in project investment levels and savings. However, the above studies have no coverage of the latest markets of Hong Kong and Taiwan, in which ESCOs are actively pursuing opportunities. Although both the Hong Kong and Taiwan governments have recognized the benefits of EnPC as a procurement arrangement, the governments' attitudes towards the use of EnPC in the two regions are quite different. With similar climatic conditions and carbon emissions reduction targets, Hong Kong and Taiwan's experiences in the market development should therefore contribute to an understanding of how governments and ESCOs can promote this procurement approach as a means to improve building energy efficiency. In the Asian region, sustained economic growth entails large consumption of energy. Hence, EnPC is a suitable alternative, especially for those building owners who lack capital and technology know-how in project implementation.

This paper aims at investigating the current market development of EnPC in Hong Kong and Taiwan, with the first objective being to compare three main aspects, namely, the potential building retrofit

works, the motivations of building owners towards the use of EnPC, and the reasons for building owners not considering EnPC. The second objective is to investigate the influence of government's incentives on the development of EnPC market, based on different situations in Hong Kong and Taiwan. The paper consists of seven sections. The first section is a discussion on the benefits of EnPC from the investment perspective. The second section presents an overview of the current situation of the electricity market and EnPC development in Hong Kong and Taiwan. The third section describes the methodology used in this paper to investigate the current market development of EnPC in the two places. The fourth section presents the results of a questionnaire survey, with direct comparisons between the above three aspects in Hong Kong and Taiwan. The fifth section summarizes the findings of structured interviews probing into governments' incentives in the two regions under discussion. This is followed by the lessons learnt based on the survey findings and interviews. The last section contains the conclusions.

Benefits of EnPC from the investment perspective

Energy efficiency investments in buildings can contribute to reductions in both operating and maintenance costs, as well as improvement of the working environment (Boyd, 2006; Warren-Myers, 2012). The Empire State Building, for example, is a 82 year-old skyscraper in New York City, where a comprehensive package of energy efficiency measures have been implemented, including air-con and lighting upgrades, use of energy management system, etc., and those upgrades are estimated to contribute 38% of energy savings per annum (The U.S. Department of Energy (DOE), 2011). On top of that, the implementation of EnPC projects is not only to guarantee the investors that the retrofitted project is undertaken with the "pay-by-savings" benefit, but ESCOs may also assist the investors in obtaining certification of green building rating schemes such as the Leadership in Energy and Environmental Design (LEED). For instance, TAIPEI 101, a landmark skyscraper in Taipei City, obtained a LEED Platinum certification under the category of existing buildings in recognition of its achievement of significant reduction in energy consumption, since 33.41 million kWh is saved annually, equivalent to savings of more than US$2 million per year (The U.S. Green Building Council, 2011). In order to provide sufficient incentives for building owners to implement EnPC projects, ESCOs often guarantee the energy cost savings more than the existing industry norm by using new technology and innovative solutions. Besides, the enhancement of property reputation by transforming the existing buildings into green buildings through EnPC projects can also contribute to the increase in the property rental and asset values (Eichholtz et al., 2013). Table 1 shows notable examples of EnPC projects around the world.

Financing mechanisms

In general, EPC projects are financed either by ESCOs or financial institutions. In the first arrangement, an ESCO finances the project with internal funds, and those ESCOs are commonly the

subsidiaries of local electric utilities. In the second arrangement, either building owners or ESCOs borrow from financial institutions for project implementation, with the ESCOs' guarantee on the amount of energy savings. The suitability of the above financing arrangements depends on a number of factors, including the credit history of borrowers, the mode of EnPC (guaranteed or shared savings), contract period, the amount of expected savings, etc (Bertoldi et al., 2006). Other alternative financing options are available in other countries, for examples, Property Assessed Clean Energy (PACE) financing in the U.S., where the local government issues municipal bonds for building energy improvement projects, and the building owners repays the bond principal and interests through an additional special assessment on their property tax bills for up to 20 years. When the property changes ownership, the remaining debt is transferred with the property to the new owner (DOE, 2014b). On-bill financing is another way to implement energy efficiency measures. Utilities companies provide finance to building owners for project implementation, and the building owners repay the loans through a surcharge on their utility bills, which in total would be lower than their bills before the retrofits (Johnson et al., 2012). Whilst PACE is predominantly used in the U.S. due to investors' strong appetite for municipal bonds, on-bill financing is used more for renewable energy development.

2. Development of EnPC market & ESCOs: Contextual Background

Hong Kong context

Hong Kong is an international city situated on the southeast coast of China, with a population of 7 million people and a land area of 1,104 km^2 (Hong Kong SAR Government (HKSAR), 2013). In 2011, the electricity consumption of Hong Kong was 151,590 Terajoule, and the electricity consumption per capita remains relatively stable at 21 Gigajoule over the past ten years. Although the industrial and transport sectors have a significant reduction of 43% and 34% in electricity use respectively, the commercial sector, which accounts for 66% of the total electricity use in Hong Kong, has experienced a gradual growth from 80,589 Terajoule in 2001 to 99,583 Terajoule in 2011 (equivalent to a 23% rise over ten years) (Electrical and Mechanical Services Department (EMSD), 2013a). To-date, the electricity tariff in Hong Kong (US$ 0.132/kWh) is significantly lower than other major metropolitan regions such as Sydney (US$ 0.228/kWh), Singapore (US$0.258/kWh), London (US$ 0.293/kWh) and New York (US$ 0.357/kWh) (CLP Power Hong Kong Limited (CLP), 2013). Due to rising fuel costs as a result of an increased use of more expensive new natural gas supplies for power generation, it is expected that the electricity tariff in Hong Kong will be gradually raised in the near future (CLP, 2013), and this situation will provide building owners with an incentive for building energy improvement projects.

Information on EnPC market in Hong Kong is scanty, especially in respect of actual turnover of EnPC projects, types of EnPC contract adopted, and nature of EnPC projects. Only some literature and presentations have revealed several notable cases of EnPC projects , mostly in office buildings,

shopping malls, hotels, hospitals and institutions (Davies and Chan, 2001). An estimate by Li et al (2000) put the potential turnover of EnPC in Hong Kong at US$100 million, but the industry has not yet actively launched measures, such as the development of local M&V and EnPC procurement guidelines, which can enhance the penetration rate of EnPC in both the public and private sectors. In public buildings, a few pilot EnPC projects were conducted in police stations, hospitals and a game hall (EMSD, 2013b). For private buildings, several EnPC projects were carried out for offices and hotels. Local studies find that the low take-up rate of EnPC is mainly attributed to 4 aspects, namely, 1) low awareness and experience; 2) complex legal and contractual issues; 3) problems with procurement process; 4) problems with measurement & verification (Davies and Chan, 2001; Hui, 2002; Yik and Lee, 2004). Until now, no specific measures to remove these barriers have been taken by the local government and the industry.

Taiwan context

Taiwan has a population of 23 million and a land area of 36,193 km^2. Taiwan is close to Hong Kong, only 700 km in distance, and both regions have a subtropical climate with distinct seasonal variations. Similar to Hong Kong, the Taiwan's electricity consumption shows a rising trend over the past decade, consuming 241,330 Terajoule in 2012 (Bureau of Energy Ministry of Economic Affairs (MOEA), 2012b). The electricity consumption per capita remains relatively constant at 10 Gigajoule over the past ten years. The industrial sector is the largest consumer, which accounted for 53.2% of the total electricity consumption in 2012, while the services sector ranked second and contributed to 19.5% of the total electricity consumption. The electricity tariff in Taiwan is US$ 0.091/kWh, ranking as the third cheapest tariff amongst 34 major regions (International Energy Agency, 2013). Due to the switch to cleaner fuel sources and huge deficit (equivalent to 80 percent of its capital), Taipower, the state-run utility company in Taiwan, is currently under great pressure of increase in electricity tariff.

Since 2008, the Taiwan government has set a target in the “Framework of Sustainable Energy Policy” that energy intensity in 2015 will be reduced by at least 20% when compared to the baseline level of 2005. In order to meet this target, the Taiwan government has been actively promoting EnPC as a means to reduce energy consumption in existing buildings (Bureau of Energy Ministry of Economic Affairs (MOEA), 2012a). At the beginning of market development, the Taiwan government appointed the Taiwan Green Productivity Foundation (TGPF) to develop the standard form of EnPC contracts and local M&V guidelines, as well as organize seminars and training courses regularly for the promotion of EnPC project implementation. Later on, the Taiwan Association of Energy Service Companies (TAESCO) and Taiwan Energy Service Association (TESA) were established (TAESCO, 2013;TESA, 2013). In 2005, the Taiwan Government launched “Subsidy Scheme for Promotion on the Use of Energy Performance Contracting”, where the eligible parties managing central and local government buildings, public hospitals and tertiary institutions can receive the subsidy of not more

than one-third of the total project costs for implementing EnPC projects (The Council for Economic Planning and Development (CEPD), 2005). Owing to the positive responses to this scheme, the Taiwan government has extended the scope of the scheme to the service industry of the private sector since 2012. From 2006 to 2012, it was recorded that 91 EnPC projects were conducted with the total project costs exceeding New Taiwan Dollar 1.186 billion (US$ 396 million) (TGPF, 2013b). Regarding financial support, the Taiwan government has successfully lined up with participating financial institutions to launch the "Preferential Loans for Service Industry Development", targeting at the service industry, including the ESCO industry, for project implementation and industry development. Loans will be made available either jointly by the CEPD and the participating bank in a ratio of 1:1 or by the bank alone using its own capital (CEPD, 2013). However, to-date, no ESCO accreditation scheme has been launched to improve services quality and professionalism. Table 2 shows the comparison of policy incentives for the use of EnPC between Hong Kong and Taiwan.

3. Methodology

Questionnaire Surveys

In order to solicit views on the EnPC market from the perspective of energy services companies (ESCOs) in Hong Kong and Taiwan, a questionnaire was designed after a comprehensive literature review and three interviews with industry practitioners. Due to different official languages being used in Hong Kong and Taiwan, the questionnaire was available in both English and Chinese versions. The questionnaire is divided in three major sections. The first section collects information on the respondents' organizational profiles. The second section is related to the ESCOs' experience on EnPC projects. The third section contains the ranking questions on three aspects, emphasizing on the types of potential building retrofit works, the motivation of building owners towards the use of EnPC, as well as the reasons for building owners not considering EnPC. ESCOs were the targeted respondents for these questions since they have been in close contact with their clients for all types of energy retrofitting works, whether carried out through general contracting or EnPC. A five-point Likert scale, where 1 denotes "least important/ least frequent/ least unlikely" and 5 denotes "most important/ most frequent/ very likely", was adopted to analyze the relative importance/frequency/likelihood of the above items. A pilot study was conducted on a small sample of respondents to ensure the readability of the questionnaire before full distribution.

Unlike other overseas countries such as Singapore and the U.S., no ESCO accreditation scheme has been launched for the recognition of local electrical and mechanical (E&M) services companies as accredited ESCOs in Hong Kong and Taiwan. In order to minimize possible coverage errors, the sampling frames in both regions were developed separately based on the latest member lists of the related trade associations. The sampling frame of Hong Kong was extracted from the member list of two relevant associations, namely, the Hong Kong Federation of Electrical and Mechanical

Contractors Limited (HKFEMC) and the Hong Kong Association of Energy Services Companies (HAESCO, 2008), whereas the sampling frame of Taiwan was constructed from two sets of member list from TAESCO and TESA. It was decided that those ESCOs who provide consultancy services only, such as energy audit and M&V work, were not included in this study, since those ESCOs often play a third-party role to monitor the performance of projects for a fee, instead of taking the roles of EnPC contractors. Besides, some of the companies in these sampling frames were discarded due to sample duplication and the nature of non-energy service companies, for examples, contractors for fire service installations.

In this research, two stages of data collection were conducted in 2013 in both Hong Kong and Taiwan. At the first stage, a total of 280 target respondents at the managerial level of ESCOs (137 target respondents from Hong Kong, whereas 143 from Taiwan) were sent a cover letter describing the study, a blank questionnaire, as well as a pre-paid self-addressed return envelope. To increase the response rate and thereby the representation of the sample, assistance of the HAESCO in Hong Kong and TAESCO in Taiwan for distributing the questionnaires to their respective members were received. Finally, 33 valid completed questionnaires were returned from Hong Kong, representing a response rate of 24.1%, whereas 32 replies from Taiwan account for a response rate of 22.3%. Table 3 summarizes the characteristics of the ESCO respondents in Hong Kong and Taiwan.

Structured Interviews

In addition to the three pilot interviews, towards the latter part of the questionnaire surveys, eight structured interviews were conducted with key industry personnel using a common set of questions, focusing on important themes relating to the ESCO market, models of EnPC, project financing, contractual issues, M&V and potential technology of building retrofit. The interviewees comprise different stakeholders, including ESCOs' experts, association representatives, building owners and financiers in both the public and private sectors of Hong Kong and Taiwan, and they also represent "organizational experts" or "key informants" working at key and responsible positions in the ESCO market. All the transcripts were sent to the interviewees for confirmation. A profile of the interviewees is shown in Table 4.

Statistical tools

Mean Score Ranking Technique

The "mean score" (MS) method was adopted to measure the importance and likelihood of different types of potential building retrofit work, EnPC motivation, reasons for building owners not considering EnPC, within the respondent groups of Hong Kong and Taiwan. Each of the items in these three sections was ranked in the descending order by their MS, and then cross-compared between the relative rankings made by the respondents from Hong Kong and Taiwan.

Cronbach's Alpha test

The Cronbach's alpha test was used to assess the internal reliability of the questionnaires. Its value ranges from 0 to 1, indicating how well the items are correlated to the others. The higher the value is, the more reliable the relative scales. Nunnally (1978) suggested that 0.6 is the commonly acceptable value for an exploratory survey. As shown in Table 5, the Cronbach's alpha values for both the Hong Kong and Taiwan questionnaires were satisfactory for all three sections.

Kendall's W test

The Kendall's coefficient of concordance (W) was carried out to measure the level of agreement and consistency within a particular survey group. The Kendall's W coefficient varies between 0 (complete disagreement) to 1 (total agreement). The Kendall's W is only applicable when the number of items in each section is equal or less than 7. If the number of questions is more than 7, the chi-square test was then used (Siegel and Castellan, 1988). When the value of chi-square is greater than the critical value at a particular level of significance (5% of significance in this study), it is concluded that a certain degree of consensus within a particular survey group exists. Table 6 shows the results of Kendall's W coefficient with Hong Kong and Taiwan survey groups in the three questionnaire sections, showing consistency of responses in each.

Mann-Whitney U test

The Mann-Whitney U test is a non-parametric test which is often applied in testing whether two independent groups of observations have the same rank distribution. If the significance is less than 5%, it is concluded that the two groups of observations are significantly different from each other. The results of the Mann-Whitney U test are showed in Table 10. An explanation of differences between the groups of Hong Kong and Taiwan on those items is given in the later part of this paper, as supplemented by interviewees and supported by the literature.

4. Survey results and discussions:

Potential building energy retrofit works

Table 7 summarizes the potential building energy retrofit work in Hong Kong and Taiwan. The ESCOs in both regions reveal that "Lighting replacement to more efficient fluorescent lamps" is the most common work for building energy retrofitting, with the mean score of 4.09 in Hong Kong and 4.20 in Taiwan. Since the use of incandescent lamps (IL) and the first generation of fluorescent lamps (FL) (e.g. T12 FL) are still common in existing buildings, reductions in electricity consumption for these installations can be simply achieved by replacing IL and T12 FL with more efficient T5 and T8 FL in commercial and industrial buildings The upfront capital for such lighting replacement works is relatively low in comparison with other energy saving technologies, and the payback period is often

less than 2 years (Mahlia et al., 2011). This less disruptive technology provides sufficient incentives for building owners to replace the inefficient lamps in existing buildings.

“Improvement of existing air-conditioning (AC) system” is another potential building energy retrofit work, with the mean scores of 3.81 and 3.63 in Hong Kong and Taiwan respectively, making it the second most common work. As AC accounts for the largest amount of total energy consumption in commercial buildings in subtropical climate (EMSD, 2013a), the energy savings on central AC can range from 5% to 30%, depending on the geographic location, use and type of buildings, operational schedules, etc. The installation of variable-speed drive (VSD) for air and water distribution system (such as water pumps and air-handling units), the optimization of central AC system, and system re-commissioning are the common retrofitting in relation to the improvement of existing AC systems (EMSD, 2007).

“Lighting replacement to light emitting diode (LED) lamps” was reckoned as the third most common building energy retrofit work in both regions. Due to the high luminous efficacy and long lifetime, the energy savings for LED lamps are substantial. Nowadays, its application is often limited to the exit signs and indicating light in buildings. However, substantial improvement in terms of lamp efficacy, color rendering and lifetime as well as cost reduction are expected in the near future (DOE, 2012b;Aman et al., 2013). A study conducted by the U.S. Department of Energy supports the view that by 2030 the market share of LED lighting will increase to 74% in all sectors, resulting in 46% reduction in electricity consumption (DOE, 2012a).

The above ranking orders in Hong Kong are similar to that in Taiwan, illustrating the potential applications of the mentioned energy saving measures in sub-tropical regions.

As shown in Table 10, the results of Mann-Whitney U test indicate that a statistically significant difference towards the potential application of heat pump systems was found between the groups of Hong Kong and Taiwan respondents. "Works involving heat pumps" were discerned as the second most common building energy retrofit with a mean score of 4.04 in Taiwan, whereas this was only ranked as seventh in Hong Kong, with a mean score of 3.34. The popularity of heat pumps as energy saving devices came about in the mid-2000s in Taiwan, with local manufacturing capacity well developed (Kwok, 2008). Due to the use of refrigeration-type cycle to provide much more heat with the same amount of energy input in heat pump systems, it is known that substantial reductions in both energy consumptions and greenhouse gas emissions can be achieved when the electric water heaters and gas boilers are replaced with heat pump systems (Kim et al., 2004). However, the survey findings show that the potential application of heat pumps in Hong Kong is less common than that of Taiwan, because of two main reasons: 1) Space and structural limitations are often observed in Hong Kong as

heat pump systems cannot provide instantaneous heating, resulting in the additional installation of large hot water storage tanks. 2) Replacement of gas-boilers with heat pump systems usually involves an additional upgrade of power supply system, including transformers and electrical switchboards. Such extra costs may be compensated by the long-term energy savings for facilities with a high demand for hot water such as hospitals, factories and hotels.

"Replacement of air-cooled chillers with water-cooled" is another item that is significantly different between the two groups of respondents as revealed by the Mann-Whitney U test. It scored only marginally lower than "Lighting replacement to LED lamps", being ranked fourth in Hong Kong with a mean score of 3.73, whereas this item is ranked as twelfth with a mean score of 2.64 in Taiwan. Although a number of studies indicate that water-cooled AC systems are more energy efficient than air-cooled AC systems (Deng and Burnett, 2000;Yik et al., 2001), due to the restriction in the use of fresh water cooling towers in most of the areas in the past in Hong Kong, air-cooled AC systems were commonly installed for non-domestic buildings before 2000. In 2008, "the Pilot Scheme for Wider Use of Fresh Water in Cooling Towers for Energy Efficient Air Conditioning Systems (FWCT Scheme)" was implemented as a standing scheme, providing a drive for such type of energy saving replacement (EMSD, 2008). Unlike Hong Kong, Taiwan has no such restriction in the use of fresh water for water-cooled AC systems. When there is no limitation in the structural capacity of buildings and spaces for the installation of cooling towers and condensing water pumps, water-cooled AC systems have been commonly used for large buildings in Taiwan.

Motivation of building owners towards the use of EnPC

Table 8 shows the motivations of building owners to retrofit buildings under an EnPC approach. "Lack of capital to implement energy saving measures on their own" was perceived as the most important motivating factor amongst 11 factors (Mean Score: 3.91). Since the merit of EnPC projects is to set off the upfront capital with the future energy and maintenance cost savings, EnPC projects are typically arranged in a way that the ESCOs pay the upfront capital or help building owners arrange project financing for project implementation. The building owner only makes the scheduled payment when the actual energy savings are materialized. This observation also applies to the Taiwan market as this factor was ranked the third place (MS: 3.97).

"Provision of turnkey services as all-in-one package, including energy audit, retrofit and financing" was ranked as the second important motivating factor in Hong Kong, with a mean score of 3.75. In comparison with traditional building energy improvement projects, EnPC projects provide comprehensive solutions for improving building energy efficiency, including energy audit, proposals of energy saving measures, project financing, project design and implementation, operation and maintenances, as well as monitoring and evaluation of savings (Bertoldi et al., 2006;Marino et al.,

2011). A similar finding was also observed in the Taiwan market as this motivating factor was rank first in Taiwan, with a mean score of 4.21. Although this factor was given a high ranking in both regions, the results of Mann-Whitney U test indicate that a statistically significant difference is observed between the groups of Hong Kong and Taiwan. This may be attributed to the current provision of incentive schemes for EnPC projects in Taiwan, where the loan tenure, interest rates, loan amount, as well as method of repayment have been standardized by the government-bank alliance (CEPD, 2013). Therefore, an all-in-one package, including the channeling of this third party financing by ESCOs, becomes important to building owners of Taiwan. In contrast, no such government financing scheme is available for implementing EnPC projects in Hong Kong. The interest rates of loans provided by ESCOs are unlikely to be competitive with that obtained through owners' self-financing. By comparison, therefore, the arrangement of project financing is less important to building owners of Hong Kong than that of Taiwan.

"Use of energy savings for other purposes may yield better return" was viewed as the third important motivating factor in Hong Kong. By implementing EnPC projects, the building owners can enjoy the benefits of retrofit work such as the cost reductions in energy bills and maintenance costs. Such cost savings can be invested for other purposes, for example, renovation of building façade and main lobby, to increase the property rents and asset prices. Based on a large cross-section of data comparison between green buildings and conventional buildings in 2009, Eichholtz et al. (2013) pointed out that it is likely that retrofitted buildings can yield higher rents and asset values in the marketplace of the U.S. This view also aligns with the situation in Taiwan where this factor was perceived as the fourth important motivating factor towards the use of EnPC.

The results of the Mann-Whitney U test show that the ESCOs of Hong Kong and Taiwan held a diverse view towards the incentive of "Transferring the technical/performance risk from clients to ESCOs". This motivating factor was ranked as the second in Taiwan with a mean score of 4.00 (Standard Deviation: 0.76), while surprisingly it was listed as the last in Hong Kong, with a mean score of 3.26 (Standard Deviation: 0.97). In principle, the risk of non-achievement of proposed savings in EnPC projects is transferred from building owners to ESCOs through the ESCO's guarantee of promised savings. Once the actual energy savings fall below the guaranteed values during each of the scheduled M&V periods, the ESCO has to compensate the agreed losses to the building owner by deducting a certain percentage from the scheduled payment. However, such a diverse view associated with transfer of performance risks may be due to non-standardization of M&V method and reporting, as well as EnPC contracts in Hong Kong. Interviewees indicate that in practice, disputes of the actual savings being achieved by ESCOs often arise in EnPC projects. During the contract period, unforeseeable changes in building operation, level of occupancy, use of premises, etc. are likely to happen to suit the latest building requirements. Sometimes, it is difficult to quantify

the impact of such changes to the actual energy savings for both contracting parties, in particular, when factors which significantly influence the building energy consumption are not well considered and documented at the beginning. Under this circumstance, the ESCO may declare that such non-achievement of guaranteed savings is attributed to changes in building operation, instead of poor performance of the retrofitted system. Unlike Hong Kong, the M&V guidelines and template for EnPC contracts have been developed in Taiwan (Public Construction Commission, 2013;TGPF, 2013a). It is expected that the performance risk will be better transferred to the ESCO when these guidelines and contract templates are well developed for local use.

Reasons for building owners not considering EnPC

Table 9 shows the top three reasons for building owners not considering EnPC in Hong Kong: (1) “Worry about its complexities” with a mean score of 4.27; (2) “Lack of familiarity with EnPC” at 4.09; (3) “Long payback period” at 3.91. The research findings in Hong Kong are consistent with that of Taiwan, suggesting that the same barriers to the wider use of EnPC exist in both regions.

The complexities of EnPC projects are mainly manifested from the development of accurate energy use baseline, negotiation of contract terms, arrangement of project financing, M&V of savings and demarcation of operation and maintenance responsibilities. Although several templates of EnPC contract and M&V guidelines have been developed overseas, such as the International Performance Measurement and Verification Protocol (IPMVP) and the Standard Energy Performance Contract (an Australian form of contract), they may not fully apply to the local use without further customization to suit different legal systems, weather conditions and market situations. The different procurement process from conventional contracting is another reason attributing to project complexities. Since EnPC projects focus more on the life-cycle costs instead of upfront investment costs (Marino et al., 2011), the direct capital cost comparison may not be a suitable tool for tender evaluation. Several researchers highlighted that the inflexibility of the public procurement process and internal accounting requirements, such as definition of ESCOs and their services (pertaining to a suitable list of tenderers amongst consultants, new work contractors, or maintenance contractors), demarcation of capital and recurrent expenditures, etc. are the reasons hampering the use of EnPC (Marino et al., 2011).

A number of researchers in many countries reveal that lack of expertise in undertaking EnPC projects is one of the main reasons hindering the wider use of EnPC (Vine, 2005;Marino et al., 2011). This survey result echoes their findings that, from the ESCOs’ perspective, building owners in both regions are unfamiliar with the arrangement of EnPC projects. In comparison to traditional "fee for service" or "design-bid-build" projects, EnPC projects possess several unique features such as the pre-retrofit energy audit, life-cycle cost approach of tender evaluation, project financing, contractual arrangement of equipment ownership, post-completion payment schedules, as well as baseline determination,

M&V method and reporting. In addition, building operation occupancy and use of premises may vary from year to year. Some interviewees opined that for those building owners who have no competent in-house engineering team, it is difficult to understand the impacts on actual energy savings when the current conditions significantly deviate from the baseline conditions.

As shown in the survey results, a long payback period is another concern of building owners implementing EnPC projects. This finding is consistent with several survey studies, pointing out that a short payback period is a necessary factor for finance managers in their consideration of project values and mitigation of project risks (Yard, 2000;Jackson, 2010). In general, the payback period depends on many factors, including size and type of buildings, operating schedules, energy prices, type of existing systems and technology used, quantum and type of project financing. Larsen et al. (2012) presented a snapshot of the ESCO industry in the U.S., reporting that the median payback period varies from 7 to 10 years for the major HVAC retrofits and on-site generation in the public/institutional sector, and 2 to 3 years for lighting retrofit in both the public and private sectors. As the owner interviewees remarked that a long payback period often implies a long contract period for EnPC projects, which may impose certain restrictions when they implement new measures in their buildings, such as a change of operation schedule, change of system set-points, alteration of premises, etc., which may lead to significant deviations from the energy use baseline conditions. The assignment of contract and title of equipment may give rise to further uncertainties when the properties with an ongoing EnPC contract are put up for sale.

5. Perspectives on EPC market in Hong Kong and Taiwan

In addition to the questionnaire surveys, eleven structured interviews were conducted with key representatives of EPC stakeholders, including the chairmen of trade associations, ESCOs' experts, building owners and financers in both regions. A profile of the interviewees is shown in Table 4.

General views on EPC models

The ESCO interviewees reckoned that the guaranteed saving model is more popular in both Hong Kong and Taiwan in comparison to the shared saving model, because it would be easier to reach a consensus that the ESCO has achieved the contractual obligation of the actual savings in excess of the guaranteed amount. In the shared saving model, however, the actual measured savings are split in accordance with a pre-arranged parentage between the building owner and ESCO. The exact amount of actual energy savings therefore becomes crucial in the project accounting, and less tolerance to measurement errors is expected under the shared saving model.

Another interviewee indicated that it would be more equitable to include the avoided cost savings, for example, due to the reduction in operating and maintenance costs, into the overall cost savings in EPC

projects. Since the replacement of ageing equipment not only generate energy savings, but also reduce the maintenance costs as the new equipment is less likely to be repaired frequently. However, this arrangement is seldom adopted in both Hong Kong and Taiwan.

Project Financing

The active participation of financial institutions is important to the development of the EPC market (Marino et al., 2011). In 2010, the CEPD in Taiwan launched a scheme, entitled "Preferential Loans to Promote Service Industry Development", to provide financial support to ESCOs for project implementation and industry development. In case of repayment default by ESCOs during the contract period, the Small & Medium Business Credit Guarantee Fund will cover the losses up to 80 percent of the loan issued by the participating bank. One interviewee commented that, despite the participating banks' willingness to provide project financing to ESCOs for implementation of EPC projects, it is still common that the ESCOs which require financing under this scheme will eventually fail to be awarded the contract, because these ESCOs have less competitive advantages than those with strong financial strength, such as self-financed ESCOs. This indicates that owners still prefer to award EPC contracts to better resourced ESCOs.

In Hong Kong, the interviewees pointed out that some local banks have established some sorts of green financing scheme for energy efficiency projects (HSBC, 2013;Standard Chartered Bank, 2013), but the relatively high interest rates hinder ESCOs and building owners from using EPC. One financer highlighted that resale values and income stream are the two main guiding principles of providing financing to customers. In EPC projects, the installed equipment and systems have no or little resale value, and the saving guarantee promised by an ESCO is not considered as a security or collateral to provide such green financing. Other legal issues, such as in the situation of multiple ownerships, the question of personal liabilities of members of the owners' management committee in the event of alleged contravention of the Building Management Ordinance in respect of the owners' decision in awarding EPC contracts not through proper procedures may raise the concerns of financial institutions. Hence, careful drafting of loan and guarantee documents is essential.

6. Lessons learnt

As shown in the survey results, lighting upgrade and air-con system improvement have the greatest energy saving potential in existing buildings under sub-tropical climate; implying that much effort should first be devoted to the development of local EnPC and M&V guidelines, specifically for these retrofits. A progressive impact has been felt in Taiwan that the local M&V guidelines have been established for different types of retrofit such as air-con, lighting and heat pump systems. These guidelines enable different parties, including ESCOs and building owners, to understand better the

whole procedures of M&V work, and thereby shorten the period of contract negotiation and avoid unnecessary disputes due to changes of baseline conditions. In Hong Kong, the usual practice of EnPC projects is often based on international guidelines, such as the IPMVP. However, these guidelines only lay down the general principles of M&V works, and other local-specific issues, such as factors significantly affecting the energy use in buildings under sub-tropical climate, have not been addressed in detail. Therefore, more efforts and time are still required by the contracting parties to negotiate the work procedures before project implementation. To improve the current situation, it is recommended that local EnPC and M&V guidelines should be developed by relevant organizations in Hong Kong specifically for the retrofitting of lighting and air-con systems.

Similar to the early stage of EnPC market development in other countries such as Australia, Singapore and the U.S., active government promotion is crucial to the wider use of EnPC in existing buildings. Benefitting from the “Subsidy Scheme for Promotion on the Use of Energy Performance Contracting" initiated by the Taiwan Government, the penetration rate of EnPC projects has been largely enhanced. From 2006 to 2012, 91 EnPC projects with different types of buildings, including public buildings, hospitals, universities, etc. were carried out with the total project cost exceeding New Taiwan Dollar 1.186 billion (US$ 396 million) (TGPF, 2013b). These experiences of implementing EnPC projects in the public sector provide good opportunities for related parties to understand the concept of EnPC in practice and identify problems such as contractual and M&V issues which may occur exclusively in the local market. Once the contractual and financial frameworks of EnPC projects are well developed and tested out, it is expected that the EnPC arrangement can be extended to the private sector with the experience gained for massive project implementation. In Hong Kong, the penetration rate of EnPC projects is still low, and those projects have mainly been implemented by the private sector. Due to the sensitive commercialism involved with the disparate private projects, these experiences cannot be effectively consolidated for improving the current practices of implementing EnPC projects. As learnt from other countries, the Hong Kong government should facilitate the market development by launching project financing schemes, standardizing EnPC contracts and M&V work. In particular, energy efficiency funding schemes should be extended to pay for shared saving arrangement or repaying guaranteed loans instead of just defraying capital expenditure.

Most interviewees asserted that a mismatch of expectations between building owners and ESCOs is prevalent in the current market of EnPC, especially in Hong Kong. In overseas business models, the typical arrangement of EnPC is targeted at those building owners who lack upfront capital to implement building energy improvement projects. However, as the interviewees pointed out, such an EnPC contract is unlikely to be formed between building owners and ESCOs in the private sector due to two main reasons: 1) The high costs of project financing as a result of the financial status of incorporated owners for premises of multiple titles; 2) Inequality of bargaining power between

intending parties due to lack of competent engineering and legal representations for contract negotiation and project management. Therefore, some of the EnPC projects in Hong Kong were arranged similar to conventional retrofitting projects for which building owners made full payment once the construction and installation works are completed, but with a guarantee on energy savings and annual reporting on the actual performance of newly installed systems. As seen in the current development of Taiwan, by introducing the loan scheme to the private sector, the financial barriers are largely overcome, but the interviewees opined that an obstacle still exists due to strict financial credibility requirements set out by the Financial Supervisory Commission (FSC), leading to failures of project financing, especially for small-medium sized ESCOs. As such, a better balance between the technical feasibility of energy saving proposals and financial capability of ESCOs should be struck in considering project financing applications. A regional database should be developed based on the empirical data of previous EnPC projects, including building characteristics, types of technology and the expected and actual energy savings achieved, so as to more accurately assess the project risks and reduce the chances of eliminating sound proposals made by smaller sized ESCOs and building owners.

7. Conclusions:

This study is to investigate the current market development of EnPC in Hong Kong and Taiwan, by direct comparisons on three key aspects, namely, the types of potential building retrofit works, the motivations of building owners towards the use of EnPC, and the reasons for building owners not considering EnPC, and to examine the different approaches of Hong Kong and Taiwan governments towards the promotion of EnPC for enhancing energy efficiency in existing buildings.

The survey unveils that lighting replacement to more efficient fluorescent and LED lamps, as well as improvement of existing air-con systems are the most common building retrofit works in both regions. Particularly noteworthy is that despite substantial energy savings being achievable by the installation of heat pumps and water-cooled air-con systems in existing buildings, space and structural limitations for the installations of those systems are common encounters in the crowded cityscape. This has limited the energy saving potential possible in existing buildings with high cooling and hot water demand.

Consistent with the pervious literature, lack of upfront capital on the part of owners and the provision of turnkey services by ESCOs are the top motivating factors towards the use of EnPC in Hong Kong and Taiwan, implying that this procurement approach can indeed provide an alternative to improve building energy efficiency, especially for those building owners who lack capital and technology know-how in project implementation. The use of energy savings for other purposes, such as renovation of building facades and main lobbies, to enhance the property rental and asset values, is also given a high ranking as a motivating factor among the two groups of respondents. Surprisingly, a

diverse view on the incentive of "transferring the technical/performance risk from clients to ESCOs" is found, implying that the guarantee of energy savings by ESCOs is not necessarily regarded as an effective risk mitigation measure against a possible shortfall of proposed savings in EnPC projects. It is believed that the genuine transfer of performance risk from clients to ESCO should be based on reliable M&V methods and reporting, as well as standardized EnPC contracts being well developed for execution by parties with a high creditability.

In terms of government policy and incentive schemes, the Taiwan government is more proactive than the Hong Kong government in promoting EnPC as a means to improve building energy efficiency in existing buildings. Several measures, such as the establishment of EnPC contract templates and local M&V guidelines, as well as project financing schemes, have been implemented to lessen the financial and technical barriers in Taiwan, while little relevant incentive schemes or measures on EnPC have been put in place in Hong Kong. As these proactive measures still need time to penetrate the market adequately, the lack of familiarity with EnPC projects and worry on project complexity are still the top inhibitors for building owners not taking up EnPC in both regions. Besides, due to long payback periods and possible legal issues regarding contract assignment and title of equipment when the subject property is put up for sale, there are still some concerns in implementing EnPC projects in both Hong Kong and Taiwan. An impetus for EnPC will perhaps arise with impending electricity tariff rises in both places.

The finding of this paper provides insightful lessons for the stakeholders, including the government, relevant trade associations, building owners, ESCOs and financiers, about the latest market development of EnPC in Hong Kong and Taiwan. Future studies could be extended to other well developed markets of EnPC, such as Australia, Japan, Singapore, and the United States, for direct comparison on the four key aspects mentioned above.

Acknowledgement

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) and the 2013 NCTU Taiwan Elite Internship Program awarded by the National Chiao Tung University to Pan Lee for a study visit to Taiwan.

References:

Aman, M. M., Jasmon, G. B., Mokhlis, H. and Bakar, A. H. A. (2013), "Analysis of the performance of domestic lighting lamps", *Energy Policy*, Vol. 52, pp. 482-500.

Bertoldi, P., Rezessy, S. and Vine, E. (2006), "Energy service companies in European countries: Current status and a strategy to foster their development", *Energy Policy*, Vol. 34 No. 14, pp. 1818-1832.

BOMA (2014), *The Building Owners and Managers Association (BOMA) Energy Performance Contracting Model*, available at: http://www.boma.org/sustainability/info-resources/Pages/boma-energy.aspx, (accessed 5 March 2014).

Bureau of Energy Ministry of Economic Affairs (MOEA) (2012a),"2012 White Paper on Taiwan Industrial Technology ", available at: http://web3.moeaboe.gov.tw/ECW/populace/content/SubMenu.aspx?menu_id=62

Bureau of Energy Ministry of Economic Affairs (MOEA) (2012b),"Energy Statistical Hand Book", available at: http://web3.moeaboe.gov.tw/ECW/english/content/SubMenu.aspx?menu_id=1537

CLP Power Hong Kong Limited (CLP) (2013),"CLP Power's 2013 Tariff ", available at: https://www.clponline.com.hk/MyHome/CustomerService/TariffOverview/Domestic/Documents/CLPTariffUpdate2013_en.pdf

Deng, S. M. and Burnett, J. (2000), "A study of energy performance of hotel buildings in Hong Kong", *Energy and Buildings*, Vol. 31 No. 1, pp. 7-12.

Eichholtz, P., Kok, N. and Quigley, J. M. (2013), "The Economics of Green Building", *Review of Economics and Statistics*, Vol. 95 No. 1, pp. 50-63.

Electrical and Mechanical Services D Aman, M.M., Jasmon, G.B., Mokhlis, H., Bakar, A.H.A. (2013), "Analysis of the performance of domestic lighting lamps", *Energy Policy*, Vol. 52 pp.482-500.

Bertoldi, P., Rezessy, S., Vine, E. (2006), "Energy service companies in European countries: current status and a strategy to foster their development", *Energy Policy*, Vol. 34 No.14, pp.1818-1832.

BOMA (2014), *The Building Owners and Managers Association (BOMA) Energy Performance Contracting Model*, BOMA, available at: www.boma.org/sustainability/info-resources/Pages/boma-energy.aspx (accessed March 5, 2014), .

Boyd, T. (2006), *Proceedings of the Pacific Rim Real Estate Society Conference, PRRES, Auckland*, .

Bureau of Energy Ministry of Economic Affairs (2012a), *2012 White Paper on Taiwan Industrial Technology*, Bureau of Energy Ministry of Economic Affairs, Taiwan, available at: http://web3.moeaboe.gov.tw/ECW/populace/content/SubMenu.aspx?menu_id=62, .

Bureau of Energy Ministry of Economic Affairs (2012b), *Energy Statistical Hand Book*, Bureau of Energy Ministry of Economic Affairs, available at: http://web3.moeaboe.gov.tw/ECW/english/content/SubMenu.aspx?menu_id=1537, .

CLP Power Hong Kong Limited (CLP) (2013), *CLP Power's 2013 Tariff*, CLP Power Hong Kong Limited (CLP), Hong Kong, available at: www.clponline.com.hk/MyHome/CustomerService/TariffOverview/Domestic/Documents/CLPTariffUpdate2013_en.pdf, .

Deng, S.M., Burnett, J. (2000), "A study of energy performance of hotel buildings in Hong Kong", *Energy and Buildings*, Vol. 31 No.1, pp.7-12.

Davies, H.A., Chan, E.K.S. (2001), "Experience of energy performance contracting in Hong Kong", *Facilities*, Vol. 19 No.7/8, pp.261-268.

Eichholtz, P., Kok, N., Quigley, J.M. (2013), "The economics of Green Building", *Review of Economics and Statistics*, Vol. 95 No.1, pp.50-63.

Electrical and Mechanical Services Department (2007), *Guidelines on Energy Audit*, Electrical and Mechanical Services Department, Hong Kong, available at: www.emsd.gov.hk/emsd/e_download/pee/Guidelines_on_Energy_Audit.pdf, .

Electrical and Mechanical Services Department (2008), *Fresh Water Cooling Towers Scheme for Air Conditioning Systems (FWCT Scheme)*, Electrical and Mechanical Services Department, Hong Kong, available at: www.emsd.gov.hk/emsd/eng/pee/em.shtml, .

Electrical and Mechanical Services Department (2013a), *Hong Kong Energy End-Use Data 2013*, Electrical and Mechanical Services Department, Hong Kong, available at: www.emsd.gov.hk/emsd/e_download/pee/HKEEUD2013.pdf, .

Electrical and Mechanical Services Department (2013b), *Seminar on Energy Performance Contracting*, Electrical and Mechanical Services Department, Hong Kong, available at: www.emsd.gov.hk/emsd/eng/pee/em.shtml, .

Energy Valuation Organization (2012), *International Performance Measurement & Verification Protocol, Concepts and Options for Determining Energy and Water Savings Volume I*, Energy Valuation Organization, available at: www.nrel.gov/docs/fy02osti/31505.pdf, .

European Commission (2014), *Energy Performance Contracting Campaign (EPCC)*, European Commission, available at: http://ec.europa.eu/energy/efficiency/financing/campaign_en.htm (accessed February 26, 2014), .

Gilleard, J.D., Wan Yeung, K.S. (2008), "Putting the yin and yang into performance contracting", *Facilities*, Vol. 19 No.5/6, pp.186-194.

HAESCO (2008), *The Hong Kong Association of Energy Service Companies*, HAESCO, Hong Kong, available at: www.haesco.hk/page/2 (accessed December 20, 2013), .

Hong Kong SAR Government (2013), *Hong Kong: the Facts*, Hong Kong SAR Government, available at: www.gov.hk/en/about/abouthk/factsheets/docs/population.pdf, .

HSBC (2013), *Green Financing*, HSBC, Hong Kong, available at: www.commercial.hsbc.com.hk/1/2/commercial/loans/general-finance/green-financing (accessed December 18, 2013), .

Hui, S.C.M. (2002), "Opportunities and challenges of energy performance contracting to improve existing buildings in Hong Kong", *Proceedings of the Joint Symposium 2002 on Achieving Sustainable Performance in Built Environment*, Hong Kong, November 19, pp.1-10.

International Energy Agency (2013), *Electricity Information 2013*, International Energy Agency, available at: www.emsd.gov.hk/emsd/e_download/pee/HKEEUD2013.pdf, .

Jackson, J. (2010), "Promoting energy efficiency investments with risk management decision tools", *Energy Policy*, Vol. 38 No.8, pp.3865-3873.

Johnson, K., Willoughby, G., Shimoda, W., Volker, M. (2012), "Lessons learned from the field: key strategies for implementing successful on-the-bill financing programs", *Energy Efficiency*, Vol. 5 No.1, pp.109-119.

Kellett, J., Pullen, S. (2012), "Prospects for energy efficiency in Australian buildings: a review of current opportunities", *Architectural Science Review*, Vol. 55 No.2, pp.92-101.

Kim, M., Kim, M.S., Chung, J.D. (2004), "Transient thermal behavior of a water heater system driven by a heat pump", *International Journal of Refrigeration-Revue Internationale Du Froid*, Vol. 27 No.4, pp.415-421.

Kwok, W.S. (2008), "Recent development of heat pump energy saving technology", Energy Monthly, Bureau of Energy, Ministry of Economic Affairs, Taiwan, June, pp.32-34.

Larsen, P.H., Goldman, C.A., Satchwell, A. (2012), "Evolution of the US energy service company industry: market size and project performance from 1990-2008", *Energy Policy*, available at: www.sciencedirect.com/science/article/pii/S0301421512007173, Vol. 50 pp.802-820.

Lee, W.L., Yik, F.W.H., Jones, P., Burnett, J. (2001), "Energy saving by realistic design data for commercial buildings in Hong Kong", *Applied Energy*, Vol. 70 No.1, pp.59-75.

Li, P. (2000), "Development of ESCOs in Hong Kong", *The Taiwan International ESCO Conference*, Taipei, September 22, .

Mahlia, T.M.I., Razak, H.A., Nursahida, M.A. (2011), "Life cycle cost analysis and payback period of lighting retrofit at the University of Malaya", *Renewable & Sustainable Energy Reviews*, Vol. 15 No.2, pp.1125-1132.

Marino, A., Bertoldi, P., Rezessy, S., Boza-Kiss, B. (2011), "A snapshot of the European energy service market in 2010 and policy recommendations to foster a further market development", *Energy Policy*, Vol. 39 No.10, pp.6190-6198.

Murakoshi, C., Nakagami, H. (2009), "Current state of ESCO activities in Asia: ESCO industry development programs and future tasks in Asian countries", The European Council for an Energy Efficient Economy 2009 Summer Study Proceedings, June 1-6, La Colle sur Loup, pp.311-322.

Nunnally, J.C. (1978), "Psychometric theory", *McGraw-Hill Series in Psychology*, McGraw-Hill, New York, NY, 2nd ed., pp.245-246.

Public Construction Commission (2013), *Model Contract for Guaranteed Energy Performance Package Deal Projects*, Public Construction Commission, Taiwan, available at: www.pcc.gov.tw/pccap2/TMPLfronted/ChtIndex.do?site=002, .

Siegel, S., Castellan, N.J. (1988), *Nonparametric Statistics for the Behavioral Sciences*, McGraw-Hill, New York, NY, 2nd ed., .

Siemens (2013a), "Energy performance contracting: why won't the private sector embrace it", Southeast Asia Building, September-October, .

Siemens (2013b), *Energy Saving Performance Contracting for a Unique Cultural and Entertainment Complex*, Siemens, available at: www.buildingtechnologies.siemens.com/bt/global/en/references/energy-efficiency-references/pages/federation-square-melbourne-australia.aspx (accessed December 20, 2013), .

Singapore Post (2008), *SingPost Wins ASEAN Energy Award 2008*, Singapore Post, Singapore, available at: www.singpost.com/downloads/media/press_release/08/PR20080807_ASEAN.pdf (accessed December 30, 2013), .

Standard Chartered Bank (2013), *Energy Efficiency Financing*, Standard Chartered Bank, Hong Kong, available at: www.emsd.gov.hk/emsd/e_download/pee/6_Energy_Efficiency_Financing.pdf (accessed December 18, 2013), .

TAESCO (2013), *The Taiwan Association of Energy Service Companies*, TAESCO, Taiwan, available at: www.taesco.org.tw/ (accessed December 20, 2013), .

Taiwan Green Productivity Foundation (2013a), *Measurement and Verification (M&V) Guidelines*, Taiwan Green Productivity Foundation, Taiwan, available at: http://escoinfo.tgpf.org.tw/Measurement_Query.aspx?Pid=04, .

Taiwan Green Productivity Foundation (TGPF) (2013b), *Successful Application of EPC Projects Through the Promotion on the Use of Energy Performance Contracting Subsidy Scheme*, Taiwan Green Productivity Foundation (TGPF), Taiwan, available at: www.ecct.org.tw/event/even-101121002.htm (accessed December 20, 2013), .

Taylor, R.P. (2008), *Financing Energy Efficiency: Lessons from Brazil, China, India, and Beyond*, World Bank, Washington, DC, World Bank, .

TESA (2013), *The Taiwan Energy Service Association*, TESA, Taiwan, available at: www.esco.org.tw/Default.aspx (accessed December 20, 2013), .

The Council for Economic Planning and Development (2005), *Promotion on the Use of Energy Performance Contracting Subsidy Scheme*, The Council for Economic Planning and Development, Taiwan, available at: http://web3.moeaboe.gov.tw/ECW/populace/content/Content.aspx?menu_id=1053 (accessed December 30, 2013), .

The Council for Economic Planning and Development (CEPD) (2013), *Directions on Preferential Loans to Promote Service Industry Development*, The Council for Economic Planning and Development (CEPD), Taiwan, available at: www.cepd.gov.tw/encontent/m1.aspx?sNo=0012887 (accessed Decemeber 20, 2013), .

The European Parliament (2006), *Directive 2006/32/EC of the European Parliament and of the Council of 5 April 2006 on Energy End-Use Efficiency and Energy Services*, The European Parliament, available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:114:0064:0064:en:pdf, .

The US Department of Energy (2011), *Advanced Energy. Retrofit Guide – Practical Ways to Improve. Energy Performance*, The US Department of Energy, available at: www.pnnl.gov/main/publications/external/technical_reports/pnnl-20761.pdf, .

The US Department of Energy (2012a), *Energy Savings Potential of Solid-State Lighting in General Illumination Applications. Solid-State Lighting Program: US Department of Energy*, The US Department of Energy, available at: http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/ssl2012_energysavings_factsheet.pdf, .

The US Department of Energy (2012b), *Multi-Year Program Plan. Solid-State Lighting Research and Development. Solid-State Lighting Program: US Department of Energy*, The US Department of Energy, available at: http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/ssl_mypp2012_web.pdf, .

The US Department of Energy (2014a), *Energy Savings Performance Contracts*, The US Department of Energy, available at: http://energy.gov/eere/femp/articles/energy-savings-performance-contracts (accessed March 12, 2014), .

The US Department of Energy (2014b), *Commercial Property-Assessed Clean Energy Financing*, The US Department of Energy, available at: www4.eere.energy.gov/wip/solutioncenter/finance_guide/content/commercial_property_assessed_clean_energy_financing (accessed March 12, 2014), .

The US Green Building Council (2011), *TAIPEI 101 Tower: LEED O+M: Existing Buildings v2009*, The US Green Building Council, available at: www.usgbc.org/projects/taipei-101-tower-0 (accessed December 22, 2013), .

Vine, E. (2005), "An international survey of the energy service company (ESCO) industry", *Energy Policy*, Vol. 33 No.5, pp.691-704.

Warren-Myers, G. (2012), "The value of sustainability in real estate: a review from a valuation perspective", *Journal of Property Investment & Finance*, Vol. 30 No.2, pp.115-144.

World Business for Sustainable Development (2009), *Energy Efficiency in Buildings: Transforming the Market*, World Business for Sustainable Development, available at: www.wbcsd.org/transformingthemarketeeb.aspx (accessed December 22, 2013), .

Xu, P.P., Chan, E.H.W., Qian, Q.K. (2011), "Success factors of energy performance contracting (EPC) for sustainable building energy efficiency retrofit (BEER) of hotel buildings in China", *Energy Policy*, Vol. 39 No.11, pp.7389-7398.

Yard, S. (2000), "Developments of the payback method", International Journal of Production Economics, Vol. 67 No.2, pp.155-167.

Yik, F.W.H., Lee, W.L. (2004), Building Research and Information, Vol. 32 No.3, pp.235-243.

Yik, F.W.H., Burnett, J., Prescott, I. (2001), "Predicting air-conditioning energy consumption of a group of buildings using different heat rejection methods", Energy and Buildings, Vol. 33 No.2, pp.151-166.

epartment (EMSD) (2007),"Guidelines on Energy Audit", available at: http://www.emsd.gov.hk/emsd/e_download/pee/Guidelines_on_Energy_Audit.pdf

Electrical and Mechanical Services Department (EMSD) (2008), *Fresh Water Cooling Towers Scheme for Air Conditioning Systems (FWCT Scheme)*, available at: http://www.emsd.gov.hk/emsd/eng/pee/em.shtml.

Electrical and Mechanical Services Department (EMSD) (2013a),"Hong Kong Energy End-use Data 2013", available at: http://www.emsd.gov.hk/emsd/e_download/pee/HKEEUD2013.pdf

Electrical and Mechanical Services Department (EMSD) (2013b),"Seminar on Energy Performance Contracting", available at: http://www.emsd.gov.hk/emsd/eng/pee/em.shtml

Energy Valuation Organization (2012),"International Performance Measurement & Verification Protocol, Concepts and Options for Determining Energy and Water Savings Volume I", available at: http://www.nrel.gov/docs/fy02osti/31505.pdf

European Commission (2014), *Energy Performance Contracting Campaign (EPCC)*, available at: http://ec.europa.eu/energy/efficiency/financing/campaign_en.htm, (accessed 26 February 2014).

Gilleard, J. D. and Wan Yeung, K. S. (2008), "Putting the yin and yang into performance contracting", *Facilities*, Vol. 19 No. 5/6, pp. 186 - 194.

HAESCO (2008), *The Hong Kong Association of Energy Service Companies*, available at: http://www.haesco.hk/page/2 (accessed 20 December 2013).

Hong Kong SAR Government (HKSAR) (2013),"Hong Kong: The Facts", available at: http://www.gov.hk/en/about/abouthk/factsheets/docs/population.pdf

HSBC (2013), *Green Financing*, available at: http://www.commercial.hsbc.com.hk/1/2/commercial/loans/general-finance/green-financing, (accessed 18 December 2013).

International Energy Agency (2013),"Electricity Information 2013", available at: http://www.emsd.gov.hk/emsd/e_download/pee/HKEEUD2013.pdf

Jackson, J. (2010), "Promoting energy efficiency investments with risk management decision tools", *Energy Policy*, Vol. 38 No. 8, pp. 3865-3873.

Johnson, K., Willoughby, G., Shimoda, W. and Volker, M. (2012), "Lessons learned from the field: key strategies for implementing successful on-the-bill financing programs", *Energy Efficiency*, Vol. 5 No. 1, pp. 109-119.

Kellett, J. and Pullen, S. (2012), "Prospects for energy efficiency in Australian buildings: a review of current opportunities", *Architectural Science Review*, Vol. 55 No. 2, pp. 92-101.

Kim, M., Kim, M. S. and Chung, J. D. (2004), "Transient thermal behavior of a water heater system driven by a heat pump", *International Journal of Refrigeration-Revue Internationale Du Froid*, Vol. 27 No. 4, pp. 415-421.

Kwok, W. S. (2008), "Recent development of heat pump energy saving technology", *Energy Monthly*, Bureau of Energy, Ministry of Economic Affairs, Taiwan, June, pp. 32-34 (in Chinese).

Larsen, P. H., Goldman, C. A. and Satchwell, A. (2012), "Evolution of the U.S. energy service company industry: Market size and project performance from 1990-2008", *Energy Policy*, Vol. 50, pp. 802-820.

Lee, W. L., Yik, F. W. H., Jones, P. and Burnett, J. (2001), "Energy saving by realistic design data for commercial buildings in Hong Kong", *Applied Energy*, Vol. 70 No. 1, pp. 59-75.

Mahlia, T. M. I., Razak, H. A. and Nursahida, M. A. (2011), "Life cycle cost analysis and payback period of lighting retrofit at the University of Malaya", *Renewable & Sustainable Energy Reviews*, Vol. 15 No. 2, pp. 1125-1132.

Marino, A., Bertoldi, P., Rezessy, S. and Boza-Kiss, B. (2011), "A snapshot of the European energy service market in 2010 and policy recommendations to foster a further market development", *Energy Policy*, Vol. 39 No. 10, pp. 6190-6198.

Murakoshi, C. and Nakagami, H. (2009), "Current state of ESCO activities in Asia: ESCO industry development programs and future tasks in Asian countries", *the European Council for an Energy Efficient Economy 2009 Summer Study Proceedings*, June 2009.

Nunnally, J. C. (1978), "Psychometric theory", *McGraw-Hill series in psychology*, 2d ed, New York, McGraw-Hill, .

Public Construction Commission (2013),"Model Contract for Guaranteed Energy Performance Package Deal Projects", available at: http://www.pcc.gov.tw/pccap2/TMPLfronted/ChtIndex.do?site=002

Siegel, S. and Castellan, N. J. (1988), "Nonparametric statistics for the behavioral sciences", 2nd ed, New York, McGraw-Hill, .

Siemens (2013a), "Energy Performance Contracting: Why won't the Private Sector Embrace it", *Southeast Asia Building*, Sept-Oct 2013.

Siemens (2013b),*Energy Saving Performance Contracting for a unique cultural and entertainment complex*, available at: http://www.buildingtechnologies.siemens.com/bt/global/en/references/energy-efficiency-references/pages/federation-square-melbourne-australia.aspx (accessed 20 December 2013)

Singapore Post (2008), *SingPost Wins ASEAN Energy Award 2008*, available at: http://www.singpost.com/downloads/media/press_release/08/PR20080807_ASEAN.pdf (accessed 30 December 2013).

Standard Chartered Bank (2013),"Energy Efficiency Financing", available at: http://www.emsd.gov.hk/emsd/e_download/pee/6_Energy_Efficiency_Financing.pdf (accessed 18 December 2013)

TAESCO (2013), *The Taiwan Association of Energy Service Companies* available at: http://www.taesco.org.tw/, (accessed 20 December 2013).

Taiwan Green Productivity Foundation (TGPF) (2013a),"Measurement and Verification (M&V) Guidelines", available at: http://escoinfo.tgpf.org.tw/Measurement_Query.aspx?Pid=04

Taiwan Green Productivity Foundation (TGPF) (2013b), *Successful application of EPC projects through the Promotion on the Use of Energy Performance Contracting Subsidy Scheme*, available at: http://www.ecct.org.tw/event/even-101121002.htm, (accessed 20 December 2013).

Taylor, R. P. and World Bank. (2008), "Financing energy efficiency : lessons from Brazil, China, India, and beyond", Washington, D.C., World Bank, .

TESA (2013), *The Taiwan Energy Service Association* available at: http://www.esco.org.tw/Default.aspx, (accessed 20 December 2013).

The Council for Economic Planning and Development (CEPD) (2005), *Promotion on the Use of Energy Performance Contracting Subsidy Scheme*, available at: http://web3.moeaboe.gov.tw/ECW/populace/content/Content.aspx?menu_id=1053, (accessed 30 December 2013).

The Council for Economic Planning and Development (CEPD) (2013), *Directions on Preferential Loans to Promote Service Industry Development*, available at: http://www.cepd.gov.tw/encontent/m1.aspx?sNo=0012887, (accessed 20 Decemeber 2013).

The European Parliament (2006),"Directive 2006/32/EC of the European Parliament and of the Council of 5 April 2006 on energy end-use efficiency and energy services", available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:114:0064:0064:en:pdf

The U.S. Department of Energy (DOE) (2011),"Advanced Energy. Retrofit Guide - Practical Ways to Improve. Energy Performance.", available at: http://www.pnnl.gov/main/publications/external/technical_reports/pnnl-20761.pdf

The U.S. Department of Energy (DOE) (2012a),"Energy Savings Potential of Solid-State Lighting in General Illumination Applications. Solid-State Lighting Program: U.S. Department of Energy", available at: http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/ssl2012_energysavings_factsheet.pdf

The U.S. Department of Energy (DOE) (2012b),"Multi-Year Program Plan. Solid-State Lighting Research and Development. Solid-State Lighting Program: U.S. Department of Energ", available at: http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/ssl_mypp2012_web.pdf

The U.S. Department of Energy (DOE) (2014a), *Energy Savings Performance Contracts*, available at: http://energy.gov/eere/femp/articles/energy-savings-performance-contracts, (accessed 12 March 2014).

The U.S. Department of Energy (DOE) (2014b), *Commercial Property-Assessed Clean Energy Financing*, available at: http://www4.eere.energy.gov/wip/solutioncenter/finance_guide/content/commercial_property_assessed_clean_energy_financing, (accessed 12 March 2014).

The U.S. Green Building Council (2011), *TAIPEI 101 Tower: LEED O+M: Existing Buildings v2009*, available at: http://www.usgbc.org/projects/taipei-101-tower-0, (accessed 22 December 2013).

Vine, E. (2005), "An international survey of the energy service company (ESCO) industry", *Energy Policy*, Vol. 33 No. 5, pp. 691-704.

World Business for Sustainable Development (2009), *Energy efficiency in buildings: transforming the market*, available at: http://www.wbcsd.org/transformingthemarketeeb.aspx, (accessed 22 December 2013).

Xu, P. P., Chan, E. H. W. and Qian, Q. K. (2011), "Success factors of energy performance contracting (EPC) for sustainable building energy efficiency retrofit (BEER) of hotel buildings in China", *Energy Policy*, Vol. 39 No. 11, pp. 7389-7398.

Yard, S. (2000), "Developments of the payback method", *International Journal of Production Economics*, Vol. 67 No. 2, pp. 155-167.

Yik, F. W. H., Burnett, J. and Prescott, I. (2001), "Predicting air-conditioning energy consumption of a group of buildings using different heat rejection methods", *Energy and Buildings*, Vol. 33 No. 2, pp. 151-166.