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The Whole Life Project Management Approach to Sustainability

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Abstract

This paper investigates sustainability in building projects from a whole life project management perspective. The objective of the research is to identify unique features of whole life project management and their relationship to building sustainability by using a case study of a social housing project. The procurement method adopted in the case study is Private Finance Initiative (PFI), which requires private contractors to manage the whole life of a project. The project reached financial close in 2007, with a contract period of 30 years. Data were collected from multiple sources including interviews, document reviews and on-site visits during a three-years period. Based on seven micro-level attributes for building sustainability, data were content analyzed to discover effective strategies used in whole life project management to achieve the sustainability objectives of the Client. The PFI procurement process increased the accountability of the private contractor in sustainability, whilst the whole life project management approaches smoothed the progress in practicing sustainable construction. The analysis results show that the whole life project management of the different project stages contributes to seven sustainable attributes in a variety of forms.

Keywords: Whole life project management, sustainability, project management, PFI, case study

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INTRODUCTION

The most acknowledged definition of sustainable development is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987). The construction industry in both developed and developing countries consumes large quantities of materials and energy. Its products have lifelong impacts on the economy, society and environment of a nation. The issue of sustainability has drawn great attention from the construction industry in recent years. Many countries have strengthened their building regulations in order to address sustainability issues such as long-term economic benefits, energy saving and environmental protections (Wang et al., 2010). The construction industry has become one of the first industries targeted to address sustainable development issues in many countries. Various researchers have focused on different aspects of sustainability issues in construction industry, such as in sustainable design (Hill and Bowen, 1997), sustainable building materials (Toman et al., 2009), and renewable energy technology for buildings (Badescu and Sicre, 2003). Wang et al. (2010) claimed that sustainable building design reduces the influences of the long-lasting manmade buildings to the environment during the buildings' whole lives.

At the operational level of the construction industry, it is the project managers' responsibility to integrate the implementation of sustainable design or technology into the construction project process. Therefore, the role of project manager is crucial in achieving sustainability in the construction industry. The whole life project management approach is a method in which the project manager continuously controls the whole life of a project including tendering, design, construction, operation and end-life, in order to achieve the project objectives of the client.

Due to public awareness of climate change and introduction of new regulations into construction industry, sustainable construction gradually becomes the long-term objective of public and private

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sectors. The strategies taken by the project managers to achieve sustainability in construction projects are crucial for the operational level of the industry. However, there is a lack of research on the benefits of whole life project management on sustainable construction. This empirical research investigates the effective strategies the project managers adopted in whole life project management and their roles in achieving sustainability objectives through a case study.

The paper is organized as follows. Section 2 provides a systematic review on the concept of whole life project management and sustainability in construction industry. Based on this review, in section 3, we describe a major council housing project in England as the case studied in this research. Research method is presented in section 4 and the case is analyzed in section 5. Section 6 and 7 are the discussions and conclusions of the research.

THEORETICAL BACKGROUND

Sustainability

An increasing number of building projects have adopted sustainability as their principal project objectives, in particular those government procurement projects that have long-term economical, social and environmental impacts on the societies. Previous research in this field mainly focused on the pre-construction stage of projects, such as the innovative and sustainable building design (Bossink, 2007; Labuschagne and Brent 2005), sustainable building assessment tools (Wang et al., 2010), and building design regulations (Hamza and Greenwood, 2009). For example, Badescu and Sicre (2003) investigated the application of renewable technologies in building industry. Hekkert and Negro (2009) studied the sustainable technological change in the construction industry.

The importance of project management in achieving sustainable construction has recently started to receive attention from researchers. A definition of sustainability for business enterprise given by the International Institute for Sustainable Development (2003) is ‘adopting business strategies and

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activities that meet the needs of the enterprise and its stakeholders today, while protecting, sustaining and enhancing the human and natural resources that will be needed in the future.' Labuschagne and Brent (2005) claimed that, in reality, sustainable development is more easily implemented into the strategic level of business than the operational level; therefore, the current project management methodology should be reviewed in order to achieve sustainable development in a business. Bieker et al. (2001) pointed out that the traditional business management systems are designed for financial performance, thus excluding the environmental and social sustainability aspects. Elkington (1997) addressed how companies adopted sustainability principles in their businesses.

Whole Life Project Management

In construction industry, the project manager's role is to integrate sustainable building design into construction and facilitate appropriate use of the building in the operational stage. Project management for sustainable building project must deal with cooperation and communication between various parties involved in different stages of the project. In conventional procurement, the design, construction and operation of engineering projects are segregated, lacking of a continuous management of the project. In this paper, whole life project management is defined as an integrated management of the commonly segregated stages within the whole life of the building and infrastructure projects from initiation, tendering, design, construction and operation. Therefore the project manager(s) must deal with the interactions between different stages and promote collaboration between different stakeholders to achieve the long-term benefits. Due to its integrated process and steadiness of the project management team, whole life project management seems more suitable for enforcing sustainability in building project. Labuschagne and Brent (2005) discussed the necessity of integrating life cycles in the manufacturing sector project management. They argued that indicators for sustainable project life cycle management should be introduced into

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project management methodologies, and they recommended the use of case studies to generate indicators in future research. Guo et al. (2010) pointed out the importance of Life-cycle management in reducing the whole life cost, time and risk and in delivering better service to the owners. Wang et al. (2012) suggested a non-deterministic budgeting approach for whole life project management. Jørgensen (2008) claimed sustainable management system must be considered from a life cycle perspective and it must include quality, environment and health and safety, so that it is the way forward for the industry. However, conventional project management in the construction industry lacks a whole life cycle perspective.

Private Finance Initiatives.

In order to improve the efficiency and sustainability of construction projects, the U.K. government introduced Private Finance Initiatives (PFI) procurement for major infrastructure projects in the 1990s (Kee and Forrer, 2002). In the U.K., it is the most implemented form of the larger scheme - Public Private Partnership (Wang and Horner, 2012). PFI transfers more responsibilities to the private sector by allowing them to finance the capital cost for projects and to manage and maintain the whole life of the asset (Wang, 2011c). The U.K. government claimed that PFI could offer better value for money (VfM) than the conventional procurement in the long term (HM Treasury, 2006; 1997). The identified advantages of PFI procurement include improved efficiency, decreased inflation, reduced public sector expenditure, innovative design and expanded private financing of capital projects (Eaton and Akbiyikli, 2005; Cheng et al., 2007; Geslera et al., 2004). Cruz and Marques (2012) suggested the local decision makers have difficulty in coping with the complex whole life management of PPP projects.

However, the other benefits such as increased sustainability in the PFI procurement projects have been overlooked by researchers. The public sector contracts out the design, construction and the operation services as a package to the private sector - Special Purpose Company (SPC) for as long

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as 30 years. It is indeed a good example of whole life project management approach. In a conventional construction contract, the project manager is only interested in the short-term gain of the construction stage. However the project managers in a PFI project have to consider the long-term performance of the building far earlier in the pre-construction stage, whilst the operational cost normally surpass the initial construction cost. The project managers pay more attention to the sustainability of the project as they have better control of the whole project by coordinating various parties at different stages. The application of whole life costing in PFI projects changed the focus of the project management from lowest construction cost to whole life performance of the building (Wang, 2011b). During the whole life of the project, the project managers' liaison with various parties increases the continuality of the project. Strong collaboration between the generally separated work parties in construction project, such as the architects and the facility managers, is established through whole life project management. Therefore different parties in the project team are able to continuously work toward the sustainable objectives of the project. A life PFI project was selected as a case study in this research, where whole life project management was adopted to fulfill the sustainability objectives of the project.

There is a large quantity of literature regarding the evaluation criteria for sustainability. The most commonly considered three dimensions for sustainability are economic, social and environmental (Jasch and Lavicka, 2006; Fernández-Sánchez and Rodríguez-López, 2010). For example, Gibson (2006) adopted five-pillar approach to assess sustainability, including ecological, economic, political, social and cultural. Hannoura et al. (2006) applied ecosystem approach to their sustainable development model. In this research, the three-dimension approach was adopted in order to assess the sustainability of whole life project management on the project level, whilst the wider impacts such as ecosystem and culture issues were excluded from the study. Fernández-Sánchez and Rodríguez-López (2010) summarized some indicators to identify sustainability in the construction

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projects on the basis of the three dimensions. The top indicators identified in their research include energy consumption waste management, ecological footprint, safety and health, life cycle replacement cost, material consumption and renewable energy. The evaluation criteria used to assess sustainable project management in Labuschagne and Brent's (2005) research included natural and human resources, stakeholder, and macro social performance in order to assess sustainable project management. In this research the criteria to evaluate the sustainability of the project management in the case study were adopted from literature and the key governmental assessment tools, for example the BREEAM and Code for sustainable homes (BRE, 2007) assessment tools. These criteria serve as the theoretical base for the measurement of sustainability in the case study. The criteria include whole life costing, energy efficiency, waste management, environment management, health and safety, community engagement, and quality, as shown in Figure 1.

THE CASE STUDY BACKGROUND

The research question was addressed through a case study. Case study method is commonly used in the project management area, because it can provide significant qualitative data and examine the true nature of the phenomena (Easton, 2010). It has been applied in studying various topics such as risk analysis (Wang, 2011b) and the cooperation between public and private sectors to develop innovations in sustainability (Bossink, 2007). More specifically, we employed a single-case study design, which is appropriate when the case represents a typical project among many different projects (Yin 2003). In this study, a PFI project was selected to investigate the effective strategies (guidelines) used for sustainable project management.

The project selected was a recent constructed average-sized PFI social housing project in England, which adopted whole life project management scheme. The prime objective of this project was to

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renovate the council housing area to create a sustainable society with better social, economic and environmental status. The scope of the project included design, refurbishment and new builds of some 1,500 council houses, including 7 multi-storey blocks, in five years, and the management of the houses for 30 years until 2037. The site area within the project scope covered around 107 hectare of land. The construction stage was started in March 2007 and completed in 2012. The overall budget of the project was over £300 million. The organization chart of the project is shown in Figure 2 below.

The project team consisted of experienced project managers for whole life project management and their industrial partners. The Client of the project was the local government, who signed the Project Agreement with the main Contractor – the Special Purpose Company (SPC) after a comprehensive tendering process of around two years. The competitive tendering process went through appraisal, business case, publishing Official Journal of European Community, prequalification of bidders, selection of bidders, invitation to negotiate, preferred bidder, contract award and finally reached the financial close in March 2007. However, due to inaccessibility, the tendering documents were excluded from the documentation analysis of this research.

The SPC managed the tendering, financing, design, construction, operation and disposal works throughout the whole life of the project according to the service requirements of the Client. Therefore, it was the SPC's responsibility to coordinate all expertise involved in the project such as design team, construction contractor, and facility management team, who was responsible for the housing and estate maintenance and management. The client intended to transfer project-related risks to the SPC and increase the value for money through PFI scheme. In the operational stage, the initial investment of the SPC was then paid back monthly over the concession period in a form of unitary payment by the client. Therefore the contractor is only paid during the operational stage for the initial investment, lifecycle replacement cost and facility management costs. Payment deduction

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might be applied if the service quality was inadequate. The indicators to measure the service quality were defined in the payment mechanism of the contract: the user satisfaction and the service availability. Any failure to match the requirement would lead to a certain amount of deduction as defined in the contract, although the amount of deduction varies according to the nature of the failure.

The Independent Certifier (IC) was a recently added role in the construction stage of PFI procurement. It was an independent party directly appointed by the client, and was responsible for checking the quality and completeness of construction works, certifying the commencement date of the operating stage of PFI project and issuing the Acceptance Certificate for the Finished Phase. The Facility Management (FM) company was responsible for the housing management and estate maintenance works during the operational stage. In order to achieve the overall project objective of sustainability, the project manager had to integrate sustainability attributes into every stage of the project from tendering, design, construction, operation to disposal.

The project management team implemented new strategies to fulfill the sustainability requirements of the client through whole life project management and achieved great success. As a result, the project management team won two national Homes and Communities Agency (HCA) Academy Awards and Co-operative Award for Excellence as a result of good management.

THE RESEARCH METHODOLOGIES

The objective of this research is to investigate the effective strategies the project managers adopted in whole life project management and their roles in achieving sustainability objectives though a case study. The research was conducted in two steps.

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In step one, we clarified the criteria we used to measure sustainability in this study. First, the contract and subcontracts of the PFI project in the case study, especially those articles that were related to sustainability issues were reviewed to investigate the defined responsibilities of the SPC on sustainability in the project management process. Then the results were compared with the seven criteria proposed by literature review. The comparison revealed that the seven criteria, acted as our theoretical framework, were also identified as the most frequently appeared terminologies in the contracts as shown in Table 1 below. They appeared as the most important sustainability goals of the project. Thus, these seven criteria were finalized to measure sustainability in project management in our study.

In step two, our main purpose was to identify the strategies used by project managers to achieve the goal of sustainability during the whole life project management. To do so, data were collected from multiple sources in order to achieve triangulation to address construct validity (Yin 2003). More specifically, they consisted of:

1) Direct observation. The first author had made 12 sequential field visits to the site during 2007-2009 and had spent a total of more than 60 hours of field observation. The activities involved observing sites, attending project meetings, monitoring project progress and reviewing a variety of project-related reports such as project monitoring reports, project process reports and due diligence reports, and having informal interviews with project managers. These activities were recorded in the form of field notes, memos and meeting minutes and were shared with the other authors.
2) Interviews. We carried out 12 interviews with key representatives of the client, the main project manager, project managers of the main subprojects, key project team members and the client. Each interview lasted 20-40 minutes and was recorded with the permission from the interviewees. The interview protocol was developed based on the seven criteria to

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evaluate sustainability identified in step one. That is, these seven aspects were the core questions to investigate how the project manager achieved sustainability goal of the client. For example, regarding **Community Engagement**, we asked the interviewee "What effective strategies has the project manager taken in order to address the Community Engagement goal in the whole project process?"

Data Analysis

The vast amount of data collected in the case study project was mostly qualitative data, which required further scientific analysis. The content analysis method translates qualitative data into numbers or percentages to conduct more accurate research (Xenarios and Tziritis, 2007). It enables quantitative analysis for qualitative data (Smith et al, 1996), therefore it is recommended by researchers in t social science. Bos and Tarnai (1999) evaluated the content analysis as a suitable tool in empirical social research. The method has been applied in various research in management, such as multi-criteria decision making (Xenarios and Tziritis, 2007), implementation of IS/IT strategy (Gottschalk, 2001). In this research, the data was transcribed and interpreted using content analysis with ATLAS.ti software (version 4.2).

More specifically, the data collected from interviews were coded and analyzed using open coding method. Open coding aims at the "breaking down, examining, comparing, conceptualizing, and categorizing data" (Strauss and Corbin 1990, p.61). Two of the authors first coded answers in each interview transcript independently to identify major categories and themes to each interview question. The results were discussed among the authors and any discrepancies were resolved before making across case (as each interviewee is treated as one case) comparisons. Then we compared the coding results across interviewees to summarize emerging patterns (i.e., the commonly used strategies in achieving sustainability). After all transcripts were finished, the authors went back to calculate how many respondents actually mentioned the different strategies in each of the seven

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dimensions of sustainability, that is, the frequency of each strategies. We believe the frequency could provide us with valuable information about which strategies were highly used.

The analysis of interview data was augmented by additional analysis of data from direct observation. This was accomplished by constantly referring to the notes and memos taken in site visits. For example, when a strategy was commonly mentioned during interviews, we referred to observations from site visits to verify its existence and how it was carried out if possible. The data analysis result showed the unique features of whole life project management and its contribution to sustainability.

THE FINDINGS

The strategies adopted in whole life project management to achieve sustainability objectives were identified in the data. The texts were coded by the phrases that represent strategies in column 2 Table 2, along with the project stages. They were categorized by the seven sustainable attributes to link with the whole life project management approach.

The frequency analysis method was used to deal with the data collected in the research. The frequencies of the appearance of the above factors in the text of various reports and notes show how many times the strategy was mentioned by various stakeholders initially in both vocal and written formats. We grouped the research findings according to the seven evaluation criteria for sustainable project management.

Environmental Management

Through documentation analysis, we found that environmental management was one of the most mentioned requirements in the contracts. According to the contract, the SPC should provide the environmental management plan to address the council's environmental requirements. The SPC

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was responsible for any environmental contamination within the project area. The SPC was also responsible to manage the Open Space and the Communal Areas within the project scope. The public area should be provided and managed to the required standards in the contracts, including the management and maintenance of un-adopted roads, pathways, verges and open space, growing trees and bushes.

According to the design requirements in the contract, the environmental friendly building material must be chosen over other materials in building the properties. The SPC had to appoint a sustainability consultant to be involved in the project management process. Therefore, during the design stage, a sustainability consultant was appointed to join the design team for the surrounding environment of the project area. The project managers sought advices from the environmental consultancy to address various aspects of sustainability attributes during the project process. For example, in reviewing the final design drawings, we found the open space increased by 10% and greenery by 15% in the public area. The environmental impacts of building materials were evaluated prior to purchasing by the sustainability consultant. During the interview, the client said they were delighted to see that "*some expensive environmental-friendly materials were chosen over cheap harmful materials*", which was unlikely to happen through the conventional procurement process. Design for whole life cost played an important role in successful environmental management. For example, one of the project managers said "*a more durable building material recommended by the environmental consultancy reduced the maintenance cost and health and safety risks, although it had a higher installation cost*".

The tenants evaluated the project deliveries as the improved environment condition of the community, which featured an "increased open and green space", "cleaner public area", and "durable and fixed outdoor facilities to reduce vandalism" by the interviewees. The project management team and the client's technical advisor carried out regular operational monitoring to

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check the quality of maintenance services provided by the FM Co. Through the document review, we found the FM subcontract adopted slightly stricter standards than the FM evaluation criteria in the Project Agreement, which meant the SPC demanded better service quality from the FM Co than the requirements of the Client. As a result, the facility managers increased preventive maintenance works in the operational stage of the project in order to identify problems as early as possible to prevent further deterioration of the facilities. Through the site visits, we found the facility managers paid more attention to the appearance of the environment of the social housing community during their daily maintenance works. The tenants appreciated the cleaner environment which in turn "affected the behavior of the tenants", as there was "less vandalism reported than before the major PFI housing renovation project started". The client claimed in the interview that "the frequency and scale of vandalism on public facilities in this area has been substantially reduced". Due to the well structured operational monitoring, any failure in the public area reported by the tenants or identified by the facility managers were rectified on time. The facilities were kept in good condition which reduced the early replacement of building elements. There was no replacement withdrawn from the lifecycle replacement fund reported during our research period.

In the interview, a project manager claimed that the main reason was due to "*strict operational monitoring regulated in the sub-contract and efficient communication with both the FM Co and the users*". Although the FM Co was newly joined in the project following the completion of the construction phase, the facility management team has established a cooperative relationship with the tenants during the previous design and construction phases. According to the project reports collected, the project management team organized four consensus meetings with the tenants aiming to increase the tenants' understanding of the environmental impacts of the design and construction methods prior to the construction commence. The project management team was able to help the FM Co to settle in the project environment and to set up relationship with the tenants in a much

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shorter period. There was no payment deduction applied on the monthly unitary charge paid to the SPC prior to the writing of this paper.

Community Engagement

By documentation analysis, we discovered that community consultation was required in the project contract to collect tenants' feedbacks on design and construction methods. According to the contract, one of the SPC's responsibilities was to reduce crime and create a friendly environment for the community. The project team regularly consulted the tenants and increased the lighting facilities in some public areas. In the interview, they claimed the "*improved living condition of the society would have a positive social impact to the area*". However, there was no official statistics available to prove the reduction on crime in the area at the time of research.

In the main contract, tenant satisfaction was a key criterion to measure the FM service performance of the SPC, which was included in the service deduction mechanism. Any negative feedbacks from the community members may lead to service deduction to the SPC. It showed, in the site visits, that the project management team paid great attention to the users' opinions during the whole project process. The project managers generally thought "*the frequent and proactive communication with the users created a better understanding*" between the two parties; therefore, "*problems could be solved promptly*". At the time of constructing this paper, there was no service deduction due to tenant satisfaction executed.

As the SPC adopted whole life project management in this project, they kept long-term consistent contacts with the users. As suggested by the project managers, they gradually built a "*friendly and trusting relationship with the tenants*", which was "*crucial for better communication and problem-solving in project environment*". During the construction stage, the SPC carried out surveys within the community to collect feedbacks from the tenants on the design and construction methods, so that minor design amendments and remedy works could be executed promptly. One of the tenants

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expressed her satisfaction of the project team: the staffs are "*tidy and clean, and nothing was too much trouble.*" The involvement of the tenants improved the client-contractor relationship and increased the users' satisfaction in the project. In the interview, one tenant said he was "*happy and their opinions had been heard and appreciated*".

Health and Safety

Given the long contract period of this project, large scope and complex combination of stakeholders, the issues related to health and safety became a crucial concern for the client and project managers. In the site visits we found that the construction of some flats overlapped with some other built flats in operation, due to the limited number of temporary settlement houses. Although the facility managers and the client's technical advisor for operational monitoring were normally unexposed to the construction phase, they often had to enter the facilities which were partially under construction and partially in use in this project. It was a big challenge for the project management team as they had to manage the health and safety issues related to all stakeholders in different project stages.

In the documentation analysis, we found that health and safety was also one of the most frequently seen terminologies in the contracts. Based on the Project Agreement, the SPC should provide health and safety documentation to a level "*appropriate and consistent with the status of the project during construction and the operational stages*".

The documentation analysis showed the operational stage was the longest phase within the contract period. The performance of the buildings and the facility management services provided by the SPC were the key measurements of the SPC services in the contract. The project management team was responsible for the maintenance of the properties and the services to the tenants. Health and safety of the occupants of the housing was another main concern in the operational stage of the PFI project. The Health and Safety reports handed in by the project managers were discussed in the

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monthly project meetings, which identified every potential health hazard and safety risk to both the workers and the tenants, and provided solutions to these risks as well. The project management team then composed health and safety handbooks for the tenants and other parties involved in the construction and operational stages of the project. Besides, regular consultation meetings with tenants were organized during the construction and operational stages of the project to identify and solve any health and safety problems. Efforts in health and safety management were paid back by the low accident rate and satisfaction of the client. In documentation analysis, we found zero major accident reported during the construction stage. There were at least four versions of project health and safety handbooks handed out for this project. The handouts in different stages addressed specific health and safety issues in various aspects. In interview, an experienced project manager said he "*had never seen so many health and safety handbooks been printed out and sent out*" and "*meetings held to address the health and safety issues in one single project*". As the project team promptly communicated with various stakeholders, the health and safety risks were well managed.

The project management team members led the whole life of the project, therefore, they remembered all the risks experienced and they were able to put them into the updated version of the health and safety reports. They believed that whole life project management "*enabled them to identify more health and safety issues during the operation*".

Quality

The documentation analysis showed the Project Agreement specified the responsibility of the SPC on the construction quality. In addition, the IC' roles included certifying milestones, extensively monitoring of construction and the review of designs, certifying level monitoring of construction, and issuing a certificate for final completion according to the IC agreement. According to the contract, the contractor could not receive unitary payment without the certificate approval of the IC, even when the house was ready for use. Therefore, the quality and process of the PFI project in

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practice were actually related to three parties including the founder's technical advisor, the SPC, and the IC. The quality failure during the construction and the operational stages of the project would cause service deduction. Therefore, the project team also strengthened the quality control system during the operational stage to avoid any service failure.

Through site visits and the review of the stage reports, it was found that the SPC, founder and the IC played an important role in quality control during the construction stage. The quality of the construction was closely related to the service performance and the maintenance and replacement works of the buildings, therefore the quality control over the construction stage of the project was emphasized by the project managers. As the independent certifier had no conflict interests with the SPC and the founder, quality control could be significantly strengthened. The founder concerned whether the value of built equity was worth their investment, therefore, their technical advisers also took part into quality assurance.

By attending project meetings, we found the SPC linked the high quality construction works with better performance in future long-term operational phase of the project. For example, the quality of construction works of the building envelop was directly related to the air-tightness of the building, which would affect the energy efficiency of the building in its operational stage. However, as pointed out by a project manager "*a poorly installed building element will cause early service failure or short life-span, and as a result increase the life cycle replacement cost of the project*" during operational stage. Therefore, they may risk for payment deduction. As the maintenance and life cycle replacement cost of the project accounted for a large percentage of the contract value, various parties paid more attention to the quality control during the construction. In the interview, the client and the tenants used "*generally satisfied*" to describe the construction quality. The facility managers said that "*due to the properly controlled construction quality, the number of rectify works*

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in the operational stage were reduced". As a result, the savings in maintenance works also contributed to a better long-term economic performance of the project.

Whole Life Costing

Through the document review we found that rather than the construction cost alone, the tendering price of the PFI project was based on the whole life costs including construction cost, life cycle replacement (LCR) cost and facility management (FM) cost of the housing project. The composition of the three cost categories of this project is 1:0.7:1.5, as calculated from the cost plan in the contract.

The initial construction cost of the project represented only one third of the whole life cost over the 30-year period, whilst the FM cost accounted for nearly half of the total whole life cost of the project. The LCR cost was a budget made for future replacement works of major building elements, which ensured that buildings could be modernized on time without concerning the inadequate funding for future major replacement maintenance. As the SPC were willing to spend twice as much as the construction cost to operate the buildings in the operational stage of the project, they paid more attention to "the long-term performance of the project" as revealed from the interviews with the project managers. For example, one project manager mentioned "*we had to make sure the building components were properly installed (during construction) by the right methods, so we won't pay to replace them before the planned cycles*.".

The life cycle fund was closely monitored during the operational stage, as shown in the operational reports. However there was also a shortcoming of using whole life cost in tendering, as being pointed out by the SPC, in which "*the tendering process was extensively long as the whole life cost plan and tender assessment were much more time consuming than those in the conventional tendering process*". As a result, the cost of the contractor at the tendering stage was

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not able to be better controlled by the project managers. Should the tendering process be appropriately adjusted and simplified, the pre-contract cost would be more appropriately controlled.

The project manager's role in the design stage was to manage the design process, and be liaison with a more complex combination of stakeholders involved in the project. Through site visits and interviews, we found that the construction contractor and facility manager in the PFI project were also invited to join the design of the buildings. It was unlike in the conventional design process where only the architects played the design role. It was a unique characteristic of the design stage of PFI project. In the design meetings, the construction and facility managers gave advices on cost, buildability, sustainability and maintainability of the designed buildings on the basis of their experiences.

One of the construction contractors said that "*the interaction between the construction contractor and the design team increased the quality of the design and ensured the delivery of the project on time and within budget*". One architect believed "*the advices from the facility managers have helped us better understanding of the long-term performance of the building elements. Therefore, the optimal design alternatives could be identified and adopted by the project team*". The advantages of mix-experienced design team in the PFI project allowed the design with more sustainable features, especially in the aspects of whole life costing such as energy efficiency, cost effectiveness, maintainability, and durability of the buildings. One of the project managers said it was "*a challenge to manage the design, construction and operation of a project, but "it gave us the full control of the project and helped us establish long-term and trusting relationships with different parties in the project team*".

Waste Management

Waste management was another main concern of the City Council, which required the SPC to address in the project in order to build a sustainable community. When reviewing the documents,

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we found the service requirements demanded the SPC to provide waste storage or segregated waste storage and disposal. For example, The "*Modern Standard life of the segregated waste storage 60 years for brickwork and 15 years for other materials*" must be included in the detailed design. Inadequate waste management service would result in service deduction on unitary payments. One of the terms in the contract said: "*waste storage and disposal area must to be kept secure from vermin and maintained in a clean condition*". The council also required the SPC to "*provide and update the waste management plan (including waste disposal and recycling) to an appropriate level at different stages of the project*". The tenants were satisfied with the waste management services delivered by the facility management team. They thought "*the improved waste management service upgraded the appearance of the community*". The application of waste assorting and recycling facilities "*created an easy to clean environment and reduced pollution to the area*".

The interviewees were asked what strategies the project management team had taken to help the delivery of a good waste management service during the project process. A facility manager mentioned "*the project managers invited us to the design process so that we could advise on the adequate quantity and quality of waste storage and facilities*". The design team planned more durable waste assorting and new recycling facilities to be installed in the properties. Sufficient temporary waste storage for the construction waste was also included in the design. As a result, the soft services regarding waste management could be performed as scheduled. By reading reports, we found that the cleaners and maintenance staff did not file any complaints about inadequate and low-quality storage or associated facilities, which was often an issue in public projects.

Energy Efficiency

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According to the contract, the energy efficiency of the managed dwelling "*must meet a minimum SAP[1] rating of 80*". If the SPC failed to meet the requirements, it would be counted as a service failure. A payment deduction would be applied to the unitary payment, which meant a reduction on the payment to the SPC by the government. The SPC was also required to "*provide advice to the tenants during the operational stage on energy efficiency measures, systems operation and repair reporting*" (excerpt from contract). The objective was to create a positive energy saving culture in the community. The energy cost was included in the bid for whole life cost in the tendering stage.

In order to achieve the Client's requirements on energy efficiency, the project management team organized design meetings with the design team, the sustainability consultant and the facility managers. They carried out cost-benefit analysis on the building envelop design. The building elements such as external wall, roof, external windows and ground floor finishes had been carefully selected based on their energy conservation performance and life cycle replacement cost rather than the initial installation cost. One interviewee mentioned that "*the insulation and air-tightness of the buildings were significantly improved in comparison to other traditional housing projects"*. One of the facility managers said "*the high specification on building envelope would save a large amount of energy costs for the tenants*". The site visits also confirmed that the efficient lighting and light control were installed in the communal areas in order to reduce the electricity consumption by lighting systems.

The energy efficiency of the buildings was closely monitored in the operational stage, and the results in the reports showed the performance of the completed buildings fulfilled the contract requirements on sustainability. Interviewees mentioned three strategies used by the project team to

[1] The U.K. government adopts SAP rating as part of national standards to measure energy efficiency of housing, scaling form 1 to 100.

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meet the requirement, as summarized below: 1) the selection of high quality building materials in design; 2) strict quality control during the construction stage; 3) and the energy efficiency-related educations given to the tenants by the facility management team in the operational stage of the buildings.

DISCUSSIONS

The case study investigated how the project management team of the SPC in a social housing project successfully achieved the project objective in sustainability. In comparison to the conventional construction contract, the PFI contract adopted more requirements and control mechanisms such as the introduction of whole life costing, IC, energy standards, service deduction, operational monitoring, environment management, and service deduction. The results showed that the sustainability idea had been embedded into the whole life project management process of the PFI project. Analysis of the data collected from document review, interviews and project monitoring of the live project in the case study revealed the benefits of whole life project management in practicing sustainability in the construction industry. The frequency of appearance of the strategies in the collected data was used to measure their importance in whole life project management. The importance of the strategies in whole life project management was shown in the frequency table (Table 3).

The mix-experienced design team and design for whole life costing were found to be the top two significant strategies for whole life project management approach to sustainability. It indicated the importance of the design stage to achieve sustainability of the whole project. The long-term performance on the economic, social and environmental impacts of the project must be considered during the design stage.

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The number 3 strategy, service deduction mechanism, provided a service standard that tied the quality of facility management with the income of the SPC. Therefore it improved the efficiency of service delivery for waste, environmental, energy, health and safety management, and community engagement. It was accompanied by another strategy, regular operational monitoring, which was ranked number 5. Almost all the selected sustainable attributes were addressed in the operational stage of the PFI project, which is the longest stage of the project.

The continuous involvement of the project management team during the whole life of the project became one of the top five important successful factors for the whole life project management contributing to sustainability objectives in the case study.

The effective communication with all stakeholders had a crucial influence on project success in this case. Most interviewees agreed that the long-term proactive and frequent collaboration between the project management team and various parties helped problem solving and the application of other strategies. In the PFI housing project, the project management team communicated with various stakeholders during different stages of the project. Some stakeholders, such as the Client and the tenants, were needed to be contacted throughout the whole life of the project. The project managers had to be liaison with all parties involved in the PFI project in order to achieve the overall objective of a sustainable housing program. The long-term contract of the PFI project encouraged the project management team communicating with the stakeholders in a different perspective. One of the project managers pointed out that their communication plan aimed to establish long-term relationships with various parties, which actually helped to build a partnership with the Client and the users rather than a sole client-provider relationship. From the design to the operation stage, the project management team had held monthly communication meetings with the tenants, and conducted regular surveys to collect their feedbacks on the progress. Any issues emerged from the

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community surveys were presented to the monthly project meetings, so that the key players in the project delivery could discuss and work together to solve the problem.

The project management team adopted the above strategies in Table 3, in order to successfully fulfill the sustainability requirements of the Client. The experts and clients in the interviews highly evaluated the effectiveness of the whole life project management approach, which contributed to the seven sustainable attributes in different stages of the project. The data analysis result, such as Table 3, was sent back to the project managers for validation purposes. All the 12 interviewees agreed that these strategies had played important roles in achieving sustainable objectives of the project. The whole life project management approach in the case study was an appropriate way to achieve sustainability in construction project. The strategies contributed to the application of sustainability during the whole process of the project, and fulfilled the sustainable development requirements of the Client. The top six strategies were more transferable across different types of projects, therefore they were the significant factors for whole life project management in achieving sustainability objectives. The rest of the strategies were more project-specific related. Therefore, they might not be able to generalize to other types of projects, such as schools. Future research should be conducted to explore the applicability of these factors on sustainability in other types of projects.

CONCLUSIONS

Whole life project management approach in a PFI project was reviewed on the basis of seven sustainability aspects. The results showed that the project management in different stages all contributed to the various aspects of sustainability. 23 success strategies for sustainable project management were identified through an in-depth analysis of a social housing PFI project in England.

Project management in the PFI project was a whole life management process ranging from the tendering and design, to the construction and operational stages of the project. The project managers

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in the PFI project had the overall control and continuality; therefore they could collaborate with various stakeholders to achieve better performance on sustainability over the whole process.

The SPC has implemented sustainable project management strategies to fulfill the sustainable development requirements of the Client in the Project Agreement. The tendering and design of the PFI project adopted a variety of criteria such as whole life cost, energy efficiency, waste management, and environment management. The construction of the buildings delivered higher quality within the timeframe and budget, due to stricter construction monitor mechanisms in the PFI procurement. The buildings in operation showed higher energy efficiency, more environmental benefits, better durability, and greater health and safety management under the PFI project management.

In order to add more sustainability features, it is recommended that the public sector should simplify the tendering process and include new requirements in the contract such as water reuse and renewable energy.

As the PFI project in the case study has not reached the end of its life yet, the disposal stage of the PFI projects is out of the scope of this research. We believe that future study on the sustainable performance review of the PFI project at the end of their lives could add more values to this research.

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Figure 1. The criteria for sustainable project management

Figure 2. The organisational structure of the PFI project

Figure1

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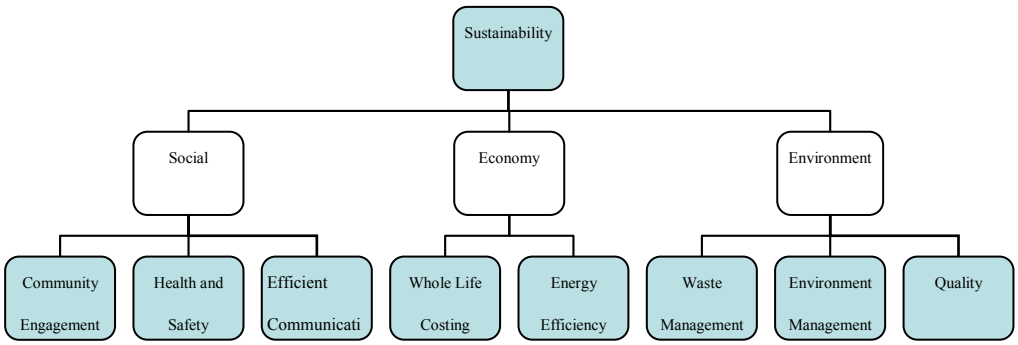

Figure 1. The criteria for sustainable project management

Figure2

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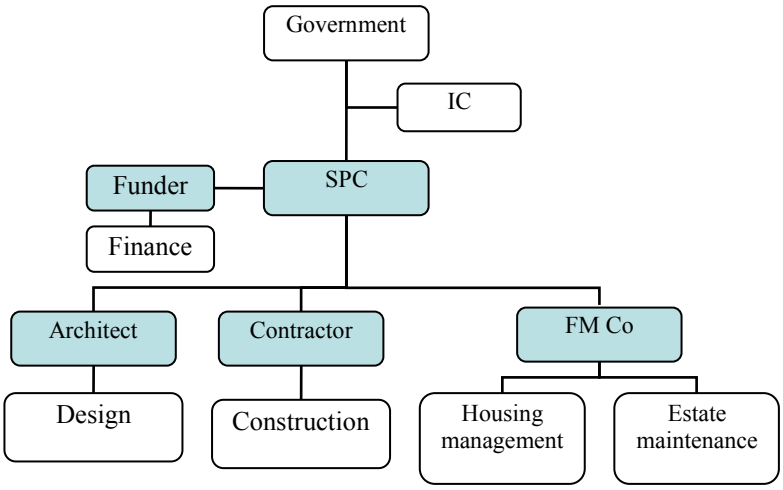

Figure 2. The organisational structure of the PFI project

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Table 1. The relative importance of the criteria to the project

No.	Requirements in contracts	Frequency	Related Criteria
1	Environment	274	Environment management
2	Tenant satisfaction	143	Community engagement
3	Health and safety	132	Health and safety
4	Quality	131	Quality
5	Sustainable/sustainability	51	Environment management
6	Waste	40	Waste management
7	Life cycle cost	28	Whole life cost
8	Tenant participation	27	Community engagement
9	Energy efficient	19	Energy efficiency

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Table 2. Strategies for sustainable project management

Sustainability Criteria	**Sustainable Project Management Strategies**	**Project Stage**
Environment management	Appointing sustainability consultant	Tendering Design
	Designing more open space and greens	Design
	Selecting environmental friendly materials	Design
	Organizing mix-experienced design team	Design
	SPC taking responsible to environmental damage	Construction
	Adopting service deduction mechanism	Operation
	Maintaining the public area in a good standard	Operation
Community engagement	Surveying for tenants' feedbacks	Construction
	Holding consulting meetings with tenants	Construction operation
	Adopting whole life project management	Construction operation
	Lighting-up to reduce crime and create friendly community	Operation
Health and safety	Reporting regularly on health and safety	Construction, Operation
	Distributing health and safety handbooks to all stakeholders	Construction, Operation
	Adopting whole life project management	Construction, Operation
	Adopting service deduction mechanism	Operation
Quality	Strengthening quality control system	Construction
	Adopting service deduction mechanism	Operation
Whole life costing	Bidding for whole life cost	Tendering
	Designing for whole life costing	Design
	Organizing mix-experienced design team	Design
	Client's involvement	Design, construction, operation

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	Adopting whole life project management	Construction operation
	Adopting service deduction mechanism	Operation
Waste management	Installing durable waste assorting and recycling facilities	Design
	Organizing mix-experienced design team	Design
	Regular operational monitoring	Operation
	Adopting service deduction mechanism	Operation
	Deliver efficient waste management service	Operation
Energy efficiency	Bidding for whole life cost	Tendering
	Increased insulation, air-tightness	Design
	Designing for whole life costing	Design
	Applicating energy standard	Construction
	Strengthening quality control system	Construction
	Adopting service deduction mechanism	Operation
	Advising tenants on efficient use of energy	Operation

Table3

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Table 3. Importance of the strategies for sustainable project management

Ranking	Strategies for sustainable project management	Frequency
1	**Mix-experienced design team**	**15**
2	**Design for whole life costing**	**13**
3	**Service deduction mechanism**	**12**
3	**Whole life project management**	**12**
5	**Regular operational monitoring**	**11**
5	**Effective communication**	**11**
7	Regular health and safety reports during construction and operational stages	10
7	Maintain the public area in a good standard	10
9	Bidding for whole life cost	9
9	Efficient waste management service	9
9	Regular surveys for tenants' feedbacks	9
12	Distribution of health and safety handbooks to all stakeholders	8
12	Lighting-up to reduce crime and create friendly community	8
14	Client's involvement	7
14	Increased insulation, air-tightness	7
16	Consulting meetings with tenants	6
16	Durable waste assorting and recycling facilities	6
18	Application of energy standard	5
18	Strengthened quality control system	5
18	Advising tenants on efficient use of energy	5
21	Appointment of sustainability consultant	4
22	Environmental friendly materials	3

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23	The SPC being responsible to environmental damage	2