# THE APPLICATION OF WHOLE LIFE COSTING IN PFI/PPP PROJECTS

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The concept of private finance initiative (PFI), later known as public-private partnership (PPP), was introduced into the UK in the early 1990s. Under the PFI/PPP scheme, a special purpose vehicle (SPV) from the private sector is generally responsible to design, build, finance and operate a public project for 20-30 years. For this reason, an emphasis is placed on the use of whole life approaches, such as whole life costing (WLC) or life cycle costing (LCC). However, few studies to date have investigated the application of WLC/LCC in PFI/PPP projects. Therefore, there is a knowledge gap in this particular field. To bridge the gap, an empirical investigation was made in the UK. The aim of this study was to explore PFI/PPP practice in terms of WLC/LCC. This study adopted a combination of a literature review, two case studies and a questionnaire survey. Qualitative data collected from the case studies and quantitative data collected from the questionnaire survey are analysed in this paper. The analysis of empirical data shows a wide embrace of WLC/LCC in PFI/PPP projects due to full control over lifetime expenditure and long-term value for money. Although WLC/LCC has been widely applied in PFI/PPP projects today, there are still some factors that affect its successful application. In order to overcome the barriers, efforts are needed from both public clients and private companies. The success of WLC/LCC in PFI/PPP practice depends on client driven optimisation, good awareness of WLC/LCC, encouragement of WLC/LCC through competitive bidding, integration of all key stakeholders into WLC/LCC, early involvement of construction and facilities management (FM) teams in design, well-established procedures and methodologies, reliability and accuracy of data, and regular monitoring the implementation of WLC/LCC.

Keywords: barrier, critical success factor, effectiveness, private finance initiative, whole life costing.

## INTRODUCTION

Traditionally, construction investment and procurement decision were based on initial capital costs, and there has been a shift from the emphasis on initial capital costs to the consideration of whole life costs (Mootanah 2005). According to the procurement guide on WLC released by the Office of Government Commerce (OGC) in 2003, the shift reflects the importance of long-term value for money. The terms WLC and LCC are often used interchangeably (Building Services Research and Information Association 2013). Many people and organisations, such as Gluch and Baumann (2004) and OGC (2003), treat them as synonyms. In the strict sense, WLC should be distinguished from LCC. For example, the British Standards Institute (BSI) defines

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life cycle costs as costs of an asset or its parts throughout its life cycle and whole life costs as all significant and relevant initial and future costs and benefits of an asset throughout its life cycle (BSI 2008). Unlike the LCC methodology focusing on costs only, the WLC methodology covers both costs and benefits during the lifetime of a project (see Figure 1). In addition, WLC includes other costs, such as non-construction cost. By comparison, WLC is wider than LCC and meanwhile LCC can be considered as part of WLC. This paper explores the application of long-term value methodologies in PFI/PPP practice. Similar to WLC, LCC represents long-term value. For this reason, both the literature on WLC and the literature on LCC are useful for

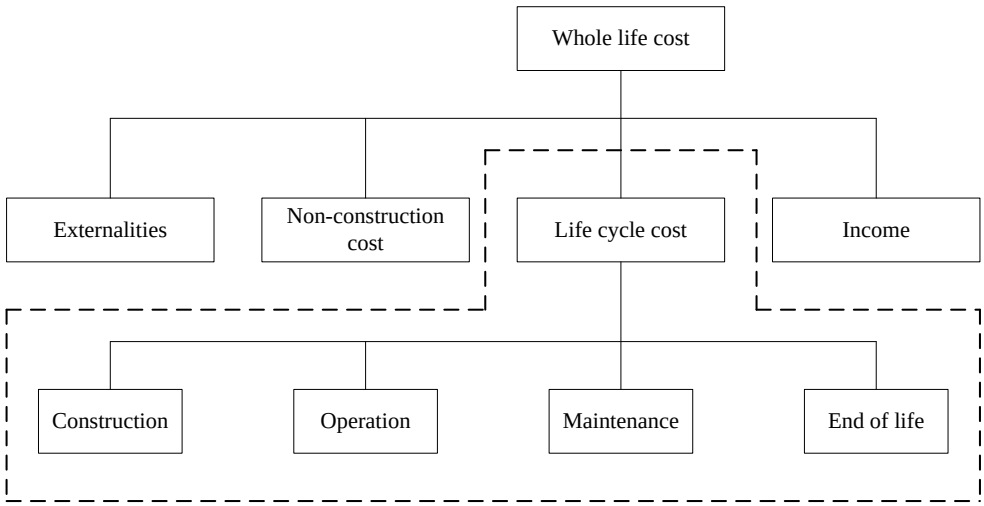


Figure 1 Relationship between WLC and LCC
Source: BSI (2008)

this research.

The literature review provides evidence to demonstrate research efforts for WLC/LCC in construction (see Table 1). For example, Woodward (1997) explained the procedure of LCC and presented a case study for the application of LCC in a transport project. Nicolini et al. (2000) discussed the possibility of applying WLC in construction projects. Sterner (2000) and Cole and Sterner (2000) identified the gap between theory and practice of LCC. Nicolini et al. (2000), Sterner (2000) and Cole and Sterner (2000) found that WLC/LCC was little used in construction practice although their importance was well recognised. According to Nicolini et al. (2000), the little use of WLC is because (1) no strong client requirements; (2) insufficient availability of reliable data; (3) lack of monitoring targets; and (4) no well-established standard methodology. Similarly, Sterner (2000) identified “lack of relevant input data” and “limited experience in using LCC calculations” as two main constraints for the implementation of LCC. In order for WLC/LCC to be better applied in construction practice, other researchers and practitioners made further efforts. For example, El-Haram et al. (2002) developed a framework for collecting WLC data in building projects to address the problem of unreliable and inconsistent data. Wu et al. (2006) analysed the impact of reliability on the improvement of WLC performance.

*Table 1: Application of WLC/LCC in construction practice*

| Author and date | Focus | Methodology | Finding |
|---|---|---|---|
| Woodward (1997) | Encouragement of using LCC | Case study | Application of LCC in a transport project |
| Nicolini et al. (2000) | Possibility of applying WLC in construction | Case study | Little use of WLC in construction |
| Cole and Sterner (2000) | Gap between theory and practice of LCC | Literature review | Key factors that limit the widespread adoption of LCC |
| Sterner (2000) | Using LCC in construction | Questionnaire survey | Main constraints for the implementation of LCC |
| El-Haram et al. (2002) | Collection of WLC data | Framework development | Addressing the problem of unreliable and inconsistent data through a data structure |
| Wu et al. (2006) | Reliability in WLC | Questionnaire survey | Improving WLC through reliability analysis |

Since the concept of PFI was introduced into the UK in the early 1990s, 717 projects have been procured by using this method with the total capital costs of £54.7 billion, in which 648 projects are operational (HM Treasury 2012). PFI is a form of PPP utilised by the UK government, in which a SPV from the private sector generally designs, builds, finances and operates a public project for a period of 20-30 years (Meng and McKevitt 2011). In addition to government budget constraints, another main reason behind the introduction of PFI is the inefficiency and ineffectiveness of project management in the public sector. The lack of efficiency and effectiveness in public projects has been criticised by a number of industry reform reports in the UK, such as Latham (1994) and Egan (1998). Introducing PFI/PPP becomes an important way of addressing this major problem (Li et al. 2005). On the other hand, PFI/PPP contracts require the private SPV to take responsibilities for the performance of a public project over a long-term. Adopting WLC/LCC methodologies improves the long-term efficiency and effectiveness (Nisar 2007). Compared to non-PFI/PPP projects, this explains why some researchers and practitioners, such as Baldwin (2003), believed that more opportunities are provided for the implementation of WLC/LCC in PFI/PPP projects.

Although in theory PFI/PPP schemes can provide more opportunities to implement WLC/LCC, few studies to date have reported the use of WLC/LCC in PFI/PPP projects. Swaffield and McDonald (2008) was one of the few studies. Swaffield and McDonald (2008) found that the use of LCC in PFI projects was often inconsistent and unstable. This meant that in some cases LCC was taken into consideration and in other cases it was ignored and replaced by the lowest capital investment, especially during busy times or when working with tight budgets. Therefore, there is a lack of empirical support for the effective use of WLC/LCC under PFI/PPP schemes. In order to have a better understanding, an empirical investigation was made in the UK through a combination of two case studies and a questionnaire survey. The research questions in this empirical study concerned (1) whether WLC/LCC is generally applied in PFI/PPP projects; (2) what is the real effect of applying WLC/LCC in PFI/PPP practice; (3) whether there are still any barriers to the use of WLC/LCC in PFI/PPP projects; and (4) what are the critical success factors (CSFs) for the implementation of WLC/LCC in PFI/PPP practice.

## RESEARCH METHODS

This study adopted a combination of qualitative and quantitative methodologies. It started with a comprehensive review of the literature on WLC/LCC and PFI/PPP. The literature review provided a background for the existing knowledge about WLC/LCC and PFI/PPP. It also provided a justification for the research topic. Subsequent to the literature review, two case studies were conducted to collect qualitative data from two hospital projects using PFI/PPP: one was in England and the other was in Scotland. The case studies were based on the interviews with senior managers/engineers in different parties involved in the two projects. The interviews were semi-structured. Some interviews took place face to face while others were through telephone, depending on the interviewees' availability and convenience. The information collected from different parties helped to generate an overall picture of WLC/LCC application in each project.

The case studies provided initial evidence for the application of WLC/LCC in two hospital projects using PFI/PPP. Although the case study methodology is good at collecting in-depth information, it lacks generalisability (Gray 2004). For this reason, the two case studies were followed by a questionnaire survey to collect quantitative data. This is because a questionnaire survey gets access to a larger population (Cargan 2007). The questionnaire survey in this research provided further evidence for the application of WLC/LCC in various projects under PFI/PPP schemes, such as hospitals, schools, courts, sport centres, social housing projects, and highways or motorways. The link between the case studies and the questionnaire survey represented a research strategy from particulars to generals. By comparison, the case studies were more in depth while the questionnaire survey was more in breadth.

As mentioned above, WLC is a wider concept that covers LCC. For this reason, the term WLC was used in this research when collecting empirical data through the questionnaire survey and case studies. The questionnaire survey targeted PFI/PPP projects. The questionnaire was divided into five sections: (1) project information; (2) application of WLC and its effectiveness; (3) benefits and barriers; (4) CSFs for the implementation of WLC; and (5) additional comments. In Section 2, the application of WLC was a Yes/No question. On the other hand, the question about the effectiveness of WLC application was answered in terms a five-point scale from "Very ineffective" to "Very effective". In order to collect in-depth information, the questions in Sections 3 and 4 were open-ended. This meant that a respondent had enough flexibility to express his/her opinions rather than only ticked boxes. The draft questionnaire was piloted with a group of five PFI/PPP experts whose comments contributed to its refinement. The questionnaire was finalised after the pilot study.

The final questionnaire was sent to 200 potential respondents via emails. The potential respondents were selected through industry contacts and social networks or using the information about PFI/PPP projects provided by the HM Treasury. They represented public clients or investors, designers, construction contractors and FM service providers from the private side. Forty completed questionnaires were returned with a response rate of 20%. The questionnaire responses were collected from different regions of the UK: England, Scotland, Wales and Northern Ireland. Approximately 80% of the questionnaire responses came from hospitals and schools, two main industry sectors using the PFI/PPP procurement method. Over 70% of the surveyed projects were during operation. The questionnaire responses provided a good sample of 717 PFI/PPP projects procured in the UK.

## ANALYSIS OF CASE STUDIES

In this research, two case studies were conducted to explore the application of WLC in PFI/PPP practice. Both of them are hospital projects running in the UK.

### Case One

Case One refers to the design, finance, construction and operation of a hospital project under the PFI/PPP scheme. It is one of the largest hospital projects in the UK, including over 800 new beds, over 20 new centres and over 20 new wards. It is responsible for meeting the healthcare need of more than 800,000 people. The concession period of this project is 25 years. WLC was undertaken at different phases of the project, such as preferred bidder, best and final offer, financial close, construction, and operation. The integration of designer, construction contractor and FM service provider was critical to the success of WLC. This project used higher quality, more expensive finishes to reduce maintenance costs in the long-term. The additional costs of providing basement service distribution tunnels and extra access lifts were paid for by the enhanced efficiencies in the movement of materials and wastes. Toilets were prefabricated in a factory to a higher quality than they would have been onsite. Prefabrication was also cheaper compared to onsite production. On the whole, this project demonstrated an optimal combination of WLC and quality to meet end users' requirements, in which the former indicated economic sustainability while the latter represented project quality and social sustainability.

### Case Two

Case Two relates to the redevelopment of nearly half of an existing hospital. It is an extension project that adds a new diagnostics centre and an outpatient centre. The client's needs and end users' requirements were well reflected throughout the design. It was the bidders' interest to estimate whole life costs and evaluate long-term commercial risks. However, the problems for the use of WLC were a shortage of relevant data and a lack of contractual incentives for WLC. Despite the problems, value for money was a main pursuit of the client. In order to win the project, the successful bidder had to demonstrate value for money. In this project, the construction team was involved early to work with the design team. For example, the mechanical and electrical (M&E) contractor and the concrete frame contractor were brought into early design meetings and their inputs contributed to the improvement of façade and buildability. Early contractor involvement enabled the successful bidder to reduce long-term costs and increase value for money. In this project, early stakeholder involvement as well as local community engagement played a critical role in ensuring the success of WLC. Good working relationships among the designer, construction contractor and FM service provider were also critical to the success of WLC.

## ANALYSIS OF QUESTIONNAIRE RESULTS

Forty questionnaire responses are analysed quantitatively in this section. Based on the two case studies, the analysis of questionnaire results provides more empirical evidence for the application of WLC in PFI/PPP practice.

### Application and effectiveness of WLC

Among 40 surveyed projects, 95% used WLC. Only 5% did not use WLC. Obviously, it demonstrates a warm embrace of WLC in today's PFI/PPP practice. WLC was only absent in a school project and a motorway project. Among 38 surveyed projects using WLC, 45% responded to "Very effective" for the use of WLC, 32% responded to

"Effective", and 23% responded to "Neither effective nor ineffective". On the other hand, there were no responses to "Ineffective" and "Very ineffective". In terms of the use of WLC and the effectiveness of WLC, the findings in this study show a great contrast between PFI/PPP projects and non-PFI/PPP projects. Compared to non-PFI/PPP projects reported by previous studies, the analysis of questionnaire results in this study demonstrates the more common and effective use of WLC in PFI/PPP projects. It gives empirical support to some researchers and practitioners, such as Baldwin (2003), who believed that PFI/PPP schemes can provide more opportunities to implement WLC. The findings bring a more promising future for the application of WLC in construction. As for the project phases in which WLC was applied, the responses were quite diverse. In spite of that, WLC techniques were applied in more than 60% of surveyed projects during early phases, such as preferred bidder. This is consistent with Zheng et al. (2008) that considered WLC forecasts central to the PFI/PPP bidding process.

**Benefits and barriers**

An open-ended question was included in the questionnaire to identify the benefits from applying WLC in PFI/PPP projects. The purpose of including such a question was to compare the benefits of WLC between PFI/PPP projects and non-PFI/PPP projects in construction. The analysis of questionnaire responses provides a list of the top five benefits: (1) increased long-term value and economic sustainability; (2) reduced costs of construction, operation and maintenance; (3) reduced needs for maintenance; (4) optimised selection of materials, equipment and components; and (5) better understanding of risks and increased certainty and transparency. By comparison, there are no big differences between PFI/PPP projects and non-PFI/PPP projects in terms of benefits of WLC. The only difference between them is perhaps that WLC in a PFI/PPP project enable both the public client and the private SPV to pursue best practice. On the other hand, the benefits of WLC may be more significant in PFI/PPP practice than in non-PFI/PPP practice. In addition to the benefits, the barriers to the implementation of WLC are also identified from the analysis of questionnaire responses, mainly including poor awareness of benefits, data problems, and lack of contractual incentives. In addition to the questionnaire survey, data problems and lack of contractual incentives are also identified from the analysis of case studies. The identification of barriers illustrates that the introduction of PFI/PPP does not imply the automatic disappearance of potential problems. Although PFI/PPP can provide more opportunities to implement WLC, efforts cannot be compromised in order to overcome the barriers.

**CSFs for the use of WLC**

CSFs were defined by Cooke-Davies (2002) as inputs to a management system that lead directly or indirectly to the success of a project or a business. Müller and Turner (2007) further considered CSFs as elements that can be influenced to increase the likelihood of project or business success. In this study, the questionnaire provided an open-ended question to identify CSFs for the use of WLC in PFI/PPP practice. The CSFs identified from the analysis of questionnaire responses mainly include: (1) contractual obligation and client driven optimisation; (2) good awareness and understanding of WLC; (3) encouragement of WLC through competitive bidding; (4) integration of all key stakeholders into WLC; (5) early involvement of construction and FM teams in the design process; (6) well-established procedures and

methodologies; (7) reliability and accuracy of data; and (8) regular monitoring the implementation of WLC.

As mentioned above, few studies to date have reported the use of WLC in PFI/PPP practice. On the other hand, existing studies has rarely identified the CSFs for the use of WLC. Although Park (2009) identified a list of CSFs for whole life performance assessment, they are related to scope, time, cost, quality, health, safety and contract administration rather than WLC. Li et al. (2005) is another study on CSFs for PFI/PPP projects. The three most important factors identified by Li et al. (2005) are: a strong and good private consortium, appropriate risk allocation, and available financial market. Obviously, the CSFs identified by Li et al. (2005) have much more relevance to the generic management system of PFI/PPP than the use of WLC under PFI/PPP in specific. For this reason, the identification of CSFs in this research fills in the knowledge gap within existing studies. It provides a useful framework for the pursuit of WLC in PFI/PPP practice. The success of WLC is more likely to be achieved if particular attention is paid to these key factors.

## FURTHER DISCUSSION

Both the analysis of case studies and the analysis of questionnaire results identify the key role of integrating all the stakeholders into WLC. In a PFI/PPP project, it means that both the public client and the private SPV need to make enough efforts for the application of WLC. For example, the public client needs to drive WLC while the private SPV needs to provide the optimal WLC model. It also means that the designer, construction contractor and FM service provider from the private side should work collaboratively together. In order to collaborate with each other, they must develop good working relationships. This explains why Smyth and Edkins (2007) highlighted the importance of relationship management in PFI/PPP projects. The analysis of qualitative and quantitative data reveals that early involvement of construction and FM teams in the design process is critical to the success of WLC. This is because it provides an important opportunity to integrate the whole team for collaborative working during the project. This is also because it enables different teams to share knowledge and experience in order to increase long-term value for money.

According to the questionnaire respondents and the interviewees involved in the case studies, WLC well reflects economic sustainability. This is similar to De Lemos et al. (2003) that considered WLC as a sustainable competitive advantage of PFI/PPP projects. Sustainable development has three pillars: economic, environmental and social. In addition to economic sustainability, WLC also contributes to sustainability in other two aspects. This is a common understanding among the industrial experts involved in the questionnaire survey and case studies. It is because WLC can be used to evaluate or appraise the technologies and solutions for environmental and social sustainability. This understanding can also be found from existing studies, e.g. Gluch and Baumann (2004) and Steen (2005) believed that WLC is helpful in assessing environmental costs and benefits over the long-term and making environmental decision. The contribution of WLC to sustainability in different aspects reveals more roles of WLC and further highlights the importance of WLC application in PFI/PPP practice. However, it is important to realise that WLC-efficient alternatives are not always the most environmentally and socially sustainable ones (Perera et al. 2009). When a WLC-efficient alternative is not the most sustainable in terms of environmental and social attributes, there is a need for the balance between economic, environmental and social benefits.

## CONCLUSIONS

This study looks at WLC from the PFI/PPP perspective. The analysis of qualitative data collected from the case studies and quantitative data collected from the questionnaire survey provides empirical evidence for the application of WLC in PFI/PPP practice. The main findings include:

- There is an increasing embrace of WLC in PFI/PPP practice to reduce long-term costs and increase long-term value for money;
- Compared to non-PFI/PPP projects, PFI/PPP projects are more likely to commonly and effectively apply the WLC methodology;
- The introduction of PFI/PPP does not help to overcome the barriers to WLC automatically, and therefore both public clients and private companies need to make enough efforts for the implementation of WLC;
- PFI/PPP provides a good platform for designers, construction contractors and FM service providers to collaborate with each other, which is a key to the success of WLC;
- WLC should be implemented as early as possible in order to generate greater benefits; and
- Close attention should be paid to some important issues, such as client driven optimisation and contractual incentives, in order to ensure the successful application of WLC.

The study on WLC application in PFI/PPP practice in ongoing. Further research can be outlined to identify how to apply WLC optimally in PFI/PPP practice. Further research is also recommended to establish incentive mechanisms for good performance and disincentive mechanisms for poor performance in terms of WLC. The only purpose of further research is to find out more space for the successful application of WLC in PFI/PPP practice.

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