

Innovative Solutions in Dutch DBFMO Projects

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ABSTRACT

Integrated building contracts are assumed to result in lower costs, better performance and more innovative solutions as a result of a collaborative environment, output specifications and long-time commitment. Life cycle costs can be reduced when investment and exploitation costs are brought in line with one another. The Dutch government gave some years ago the green light for the Public Private Partnership (PPP) model to be applied in the construction and renovation of government real estate. This means that market parties can become involved in renovation and new-build projects, but also in maintenance, facility services, operation and financing. DBFMO (Design, Build, Finance, Maintain & Operate) is the core of public-private partnerships. The DBFMO model covers the entire process, from the production of a design to a fully operational building with all the associated services. A study was focused on finding empirical evidence for product innovations effecting maintenance costs and energy-use in DBFMO office projects compared to traditional delivered office projects. It is assumed that in DBFMO contracts innovations effecting maintenance and energy-use are of direct benefit for the contractor and thus the most easy to find. Two DBFMO office projects were compared with five traditionally delivered office projects. Applied research methods were explorative interviews with clients and contractors about DBFMO contracting, case-studies focusing on maintenance costs and energy-use calculations and expert interviews with contracting parties. Within the DBFMO projects four products and design choices can be considered to be innovations effecting maintenance costs and energy-use. Besides some incremental maintenance process innovations were found. The innovations found can be considered as the successful transfer of knowledge between consortium members that would have worked separately in case of a traditional build project.

KEYWORDS: DBFMO, Energy-use, Innovation, Maintenance Costs

1 Introduction

The Dutch government wants to enforce DBFM(O) contracting to realize the construction, maintenance and operation of properties, including their real estate on which this research is focusing, like central government offices and penitentiaries. The decision to use a PPS model for accommodation services with an expected sum above € 25 million is based upon the outcomes of a 'public-private comparator', calculating the expected qualitative and quantitative extra value of PPS compared to a traditional model. The Governmental Buildings Agency tenders the DBFMO contracts. The tendering procedure involves a competitive dialogue, according to the EU public procurement procedures, inviting three bidders. More bidders would result in too high transaction costs for the construction market and the client. At the end of the PPS-tendering a preferred bidder is chosen that has offered the economically most advantageous offer (EMAT). The concession period is 20 or 25 years.

Evaluations by the Ministry of Finance show that, compared to traditional projects, DBFM(O) projects result in extra value between 10 and 15% and are delivered on time and within the budget (Ministry of Finance, 2011). DBFMO projects for schools hardly exist in the Netherlands. The main reason is that the budget for construction and the budget for maintenance and operation are managed by separate institutions. Also there are no DBFMO projects for care buildings, mainly due by the lack of clarity of given the complexities financing the care system.

The DBFMO model covers the entire process, from the production of a design to a fully operational building with all the associated services. An integrated approach is the keyword here. The idea behind this approach is that better and most likely cheaper buildings can be developed when the consequences of a particular design are thoroughly examined in the early stages of the development process. Life cycle costs can be reduced when investment and exploitation costs are brought in line with one another. The Ministry of Finance advocates for future projects gave a scope for operational services as great as possible, to maximize the benefits of DBFMO. Shared Service Organisations of the Dutch Government will control the contracts during exploitation (Ministry of Finance, 2011).

Several benefits are often assumed, with regard to these project types as listed by amongst others Blayse and Manley (2004), Akintoye *et al.* (2005) and Leiringer (2006): lower project cost, shorter construction time, competitive advantage, higher overall quality of the end product and benefits accruing from letting the private sector be innovative in its solutions.

In the Netherlands the emphasis of PPP and DBFMO contracts is on better performance and lower costs. This compared to the UK where in PPP/PFI contracts private finance is the core, because of the enormous quality backlog in public buildings and infrastructure and the lack of public finance. Edkins *et*

al. (2011) studied the use of the PFI as a procurement method for capital school projects. Their results include that total facility services costs in PFI schools are higher (though not significantly) in six of nine of the elapsed years following renewal. In the Australian PPP context the designers or architects within a PPP project are regarded as ‘subcontractors’ to others and may be treated simply as a provider of services rather than generators of innovative solutions Raisbeck (2008). In the Dutch DBFMO model output specifications, an architectural ambition document, the EMAT criteria and the value per criterion, are aimed to steer architectural quality and provide room for innovations. During a competitive dialogue period before the Bid and Final Offer, the architect can speak a few times with the users of the building. Innovations have to prove themselves in lower costs or higher performance. Architectural quality is almost not quantifiable except by expert judgment (Fokkema, 2009; Prins, 2009; Volker, 2010).

2 Conditions for an innovative environment

The research aims to find empirical evidence for the assumption that DBFMO projects stimulate innovations effecting maintenance costs and energy-use. The supposed conditions to achieve innovations within DBFMO projects compared to traditional projects are the integration of activities and therefore a more collaborative environment, the use of output specifications, the possibility of optimizing costs and performance through whole life commitments and risk transfer from public to private parties. These issues will be further discussed, because they appear not to be as obvious as they might look at first sight.

The first argument is about the collaborative environment. A consortium is responsible for the delivery of several activities over a relatively long time period (20-30 years). Therefore a common view is that this could lead to better collaborative working between the different disciplines involved. Sogol (2010) found that even in case of large developing contracting firms, there appears to be a lot of inefficiencies between the different departments in terms of collaboration and the strive to optimize project outcomes. In practice often a special purpose vehicle is established which is concerned with the bidding. Even within DBFMO projects there might be struggles between the construction department and the departments responsible for operations like maintenance and facilities management. The different activities are often subcontracted separately by the special purpose vehicle, resulting in fragmented interests and non-collaborative working, as is the case in traditional projects. Leiringer *et al.* (2009) present a case study of a large construction firm in the UK that works with PPP projects. The case study clearly illustrates how managers responsible for service operations struggle in having any real impact on key design and construction decisions.

Whereas traditional project delivery approaches focus on a detailed description of buildings, within DBFMO projects performance specifications are being used. A provider can therefore choose solutions

that are able to deliver the performance in the most efficient way (Sexton & Barrett, 2005). In a publication of the Dutch Regieraad Bouw (2005) it is claimed that formulating the demand in performance specifications is an important stimulant for letting a provider be innovative in choosing a solution. The output specifications and the award criteria, especially the weighted value per criterion, steer the architectural quality and the room for innovations (Fokkema, 2009). However, Leiringer (2006) suggests that due to the performance approach a provider will likely choose a solution that fits best to the existing knowledge and available techniques within their organization, so reducing project risk, instead of choosing new or unique innovative solutions.

The focus within DBFMO projects is on providing accommodation services for a given period and less on the physical building as a product delivered at a certain moment in time. Due to the longer obligations it can be suggested that a DBFMO provider focuses on life cycle costing by optimizing initial investments and operational costs. Nevertheless studies like those of Leiringer *et al.* (2009) and Sogol (2010) claim in their case studies that there is little contact between the maintenance and construction department and therefore the possibility to influence the design is minimal: "Such decisions remain dominated by an institutionalized mindset that prioritizes traditional cost cutting over any consideration of through-life operational value" (Leiringer, et al., 2009).

Sogol (2010) found in a case study executed at a large developing contractor, that the traditional differences in organisational culture, even in case of integrated projects, largely is hindering good collaboration between the different departments involved.

The last argument for an innovative environment of DBFMO projects is about the risk transfer from the public side to private parties. The PPP approach is most effective if the party that is best able to control a particular risk also bears the risk in question. This can be beneficial to a public client because the chances for budget overruns are smaller (HM Treasury, 1999). Whether a larger risk transfer to private parties will lead to innovative solutions is questionable (Leiringer, 2006). Especially the development and application of innovative solutions entails additional risk, therefore the doubt in the previous mentioned reasoning seems logical.

3 RESEARCH QUESTION AND METHODOLOGY

3.1 Research question

It might be concluded that there are different opinions and types of reasoning whether or not a DBFMO provider will be innovative in its solutions to deliver the accommodation services asked for. However evidence for this of researched building projects is very scarce. The main research question of

the performed study is: Do DBFMO office projects contain solutions that effect maintenance costs and energy-use? It is assumed that in DBFMO contracts innovations on these aspects are of direct benefit for contracting parties and thus the most easy to detect.

3.2 Research methodologies

First, in order to get a better understanding of innovations from a maintenance and energy-use point of view, and to define these, explorative interviews were held with staff members of a large construction firm, an architect's firm and a client, all involved in DBFMO projects. In total 11 people were asked the following questions: (1) How to define innovations effecting maintenance costs and energy-use within a context of DBFMO projects? and (2) how to find and to measure these innovations?

Further, qualitative case study research was applied as part of an engagement with a construction company, which has executed a large number of PPP and DBFMO projects in the Netherlands. This company is a leading DBFMO contractor at the Dutch market and has provided the data that was needed to conduct this research. The case study research held two DBFMO projects each consisting of two components. First the 'better performance' on maintenance costs and energy-use had to be defined. Second a maintenance and energy cost analysis was used to get an idea where possible innovations on elements or their aggregations could be found. Indications resulting out this cost analysis of a better performance by lower maintenance costs of elements or lower energy use were discussed, in terms of their possible innovation behind, by means of expert interviews. For this seven interviews were held with staff members from different departments and advisors involved in the design phase of the DBFMO projects. Per better performing, in terms of cost, element on maintenance costs or on energy consumption the interviewees were asked the following questions: (1) Can the better performance be understood by other design choices or the application of other products?; (2) Is the motivation for other design choices and other products direct or indirect?; in other words do they focus on reducing maintenance costs and/or energy-use, or is it a secondary advantage?; (3) Can the applied design choice or product be seen as innovative as defined in this research? and (4) Is the design choice or product project specific or not project specific?

3.3 Innovation

The concept of innovation and its definition is frequently debated. Construction innovation literature emphasize often technical product innovations to compete in the market (Blayse & Manley, 2004). Garcia and Calatone (2002) define technological innovation as an iterative process initiated by a the perception of a new market and/or a new service opportunity for a technology based intervention which leads to

development, production and marketing tasks striving for the commercial success of the invention. Slaughter (1998) defines innovation as the actual use of a nontrivial change and improvement in a process, product, or system that is novel to the institution developing the change. All definitions mean that innovations stand for more than knowledge development; they should be implemented. Second the innovation is the whole route from knowledge development till market introduction. Finally, products, processes, services and/or organizational structures are new for the own organization. In case of determining innovations in DBFMO projects effecting maintenance and energy-use, these definitions should be made operational.

3.4 DBFMO context

When a DBFMO contract is applied, the client is demanding an accommodation service instead of a building delivered as a product at a certain moment in time. Within a predetermined performance specification a client buys usable space or functionality for a certain period. This is in sharp contrast with a traditional contract where an amount of square meter floor area is bought as a building. A provider of a DBFMO project delivers the accommodation services through a system consisting of process parts and physical parts. The process parts consist of different activities that have to be performed during the contract period: designing, building, maintaining and operating the physical parts. Based on decomposition models for design decision making, a building is decomposed in physical parts in terms of single elements, components, component compositions and ensembles. Components and their aggregations must have meaning in terms of usage, construction and/or their life cycle, and as such are meaningful for design decisions as well as maintenance and operations (Prins, 1992).

The process parts were not investigated within this research, because it is not clear how the process parts influence exactly the design decisions and whether they stimulate innovations. So it is assumed that all the supposed advantages of the integrated process parts have to work out on the physical parts of the structure (components, component compositions and ensembles).

3.5 Innovations effecting maintenance and energy-use

The explorative interviews show that innovations by almost all respondents (10) are seen as a result of the systematic application of life cycle costing. The application of products and design choices that in a traditional setting are considered to be too expensive, can be seen as innovative. The majority of the interviewees answered on the second question that innovations effecting maintenance costs and energy-use can be found in the design process in terms of low life cycle cost solutions and in the physical parts of the structure due to the uniqueness of product choices and materials.

Based on the outcomes of the explorative initial study, innovations effecting maintenance costs and energy-use are defined as: A better performance compared to similar traditional build projects by developing and applying new and improved design solutions and products in the physical parts of the building (elements, components, component compositions and/or ensemble level), which are integrated into a structure and delivering accommodation services at an agreed level for a predetermined period.

Innovation according to this definition is not a goal on itself, but has to contribute value to the accommodation services. Innovation is measured via the so-called object method, meaning that innovations themselves are investigated and not the company that creates the innovations (Archibugi & Sirilli, 2001). The possible innovations are classified into project specific and project non-specific innovations, due to the 'relative' unique nature of buildings.

4 CASE STUDIES

4.1 DBFMO projects

Two DBFMO projects from a large contractor in the Netherlands were investigated. Long-term maintenance budgets and expected energy consumption were compared with those of five traditional delivered projects to identify innovations. The traditional projects were selected based on criteria for their properties in terms of comparability. As no standardized cost databases are available for this the data of the traditional projects was received from maintenance consulting firms and facility management organizations involved in the projects analyzed. In Table 1 the different characteristics of the cases and projects studied as well as the methods used for data retrieval are shown.

4.2 Maintenance costs data-analysis

Comparing buildings on maintenance costs is difficult due to the unique nature of buildings as a whole. "Every building is affected by its location, height, composition, energy consumption and a plethora of other differentiation points – all of which make each building unique" (Hughes, *et al.*, 2004). When a building is decomposed to smaller parts e.g. elements, the uniqueness is more relative. Maintenance costs are generally found in practice, related to a classification in elements. The maintenance costs were not re-classified and aggregated to components, component compositions and ensembles. Besides practical reasons for not doing this, it was not a necessity because the cost analysis is used to get an idea where possible innovations on elements or their aggregations could be found. Also according to the applied definition it might be assumed that components and their aggregations are project specific and cannot easily be compared.

Table 1 Characteristics DBFMO cases and traditional projects

| | Case DBFMO 1 | Case DBFMO 2 | Trad 1 | Trad 2 | Trad 3 | Trad 4 | Trad 5 |
|--------------------------------------|-----------------|-----------------|----------|----------|-----------|-----------------|----------------|
| Location | The Hague | Groningen | - | - | - | Middel- burg | Apel- doorn |
| Function | Office | Office | Office | Office | Office | Office | Office |
| Building type | Low-rise | High-Rise | Low-rise | Low-rise | High-rise | Low-rise | Low-rise |
| Project size (GFA) | 68,000 | 48,000 | 12,500 | 25,000 | 50,000 | 12,000 | 14,000 |
| Floors | 5 | 24 | 5 | 5 | 23 | 5 | 5 |
| Maintenance quality (1) | 3 | 3 | 3 | 3 | 3 | - | - |
| Consideration period (years) | 25 | 20 | 40 | 25 | 30 | - | - |
| Operating time (hours per day) | 14 | 13 | N/A | N/A | N/A | N/A | N/A |

(1) Minimum condition mark on a six-point condition scale (Straub, 2009)

4.3 Comparative data

According to Daly *et al.* (2003) a number of factors have a strong influence on the maintenance costs. To compare the different office buildings on maintenance costs, the factors shown in Table 2 were identified. These factors were used, given the characteristics of the two DBFMO cases, as for the selection of traditional build projects getting comparative data and to correct the data by differences in building characteristics.

A long-term maintenance plan is in essence an activity planning where dissimilar sequences of costs are modeled for a certain period. In the different maintenance plans different types of maintenance are identified. In the analysis the following types of technical maintenance were taken into account: preventive maintenance, corrective maintenance and replacements. Besides the nominal value, the net present value as calculated, was used to compare different sequences of costs. The net present value method seems more suitable because identical project lives are taken into account in the comparison. The maintenance costs are calculated per element in €/m² gross floor area (GFA).

Table 2 Data DBFMO projects and traditional projects

| | Comparison | Data corrections |
|----------------------|----------------------------|--|
| Year of construction | After 2001 | - |
| Project size | Over 10,000 m ² | - |
| Number of floors | - | Indicative |
| Maintenance quality | Equal or higher if DBFMO | - |
| Gross floor area | Equal | Corrections per m ² GFA |
| Consideration period | Over 20 | - |
| Operating time | Equal | Corrections |
| Price level | Equal | Corrections using building costs index |

Within maintenance to the building structure the costs for floor finishing and ceiling finishing are good comparable being almost equal to the gross floor area of a building. Elements like façade finishing and roof finishing can result into disturbing outcomes due to different shape factors. For the building services the following elements seem to be comparable: heat generation, cold generation, ventilation and lighting.

4.4 Energy-use data-analysis

The energy consumption of a building is also related to a number of factors, which are mostly unique per building. In the research the energy performance is expressed in consumption per gross floor area instead of costs. Energy costs are affected by the oil price which can give a disturbing effect in a comparison. According to a publication of SenterNovem (2007) the following factors can be distinguished that influence the energy consumptions in buildings: function, project size, year of construction and the operating time. With regard to energy consumption the use of gas and electricity was taken into account and are diverted into the unit Mega Joules (MJ) per year/m² GFA.

5 FINDINGS

5.1 Maintenance costs projects

For case one only the structural maintenance costs could be analyzed because the cost data for the building services maintenance were not available. The values shown in the Figure 1, 2, and 3 are nominal values because the net present values showed a similar trend as the nominal values. The absolute values as shown in the graphs are fictitious, the relative differences are real.

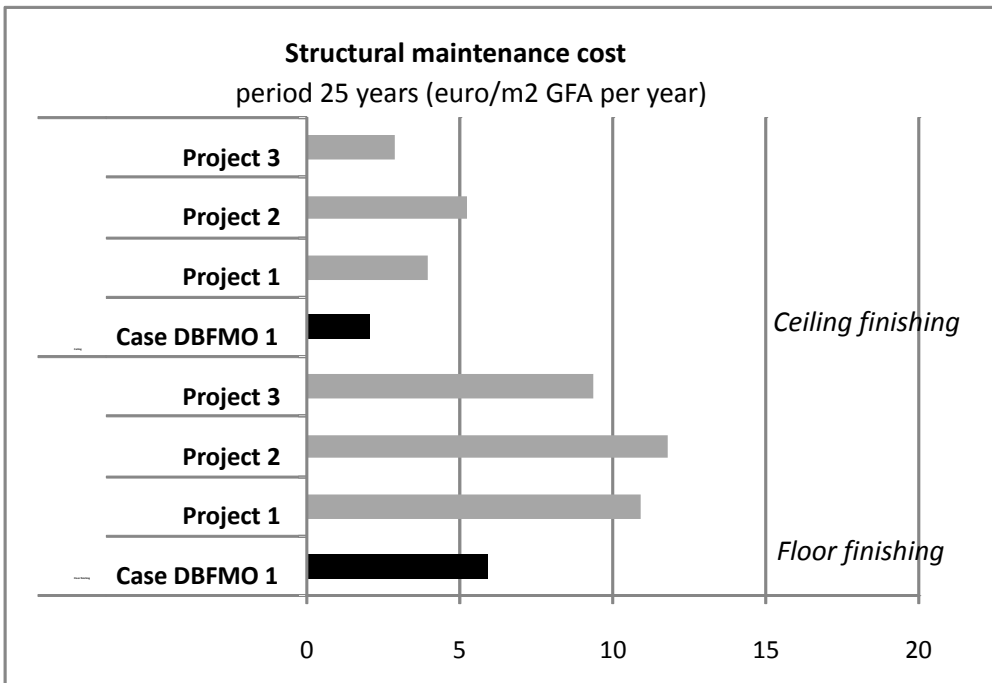


Figure 1 Maintenance costs floor and ceiling finishing DBFMO project 1 and traditional projects 1,2 and 3

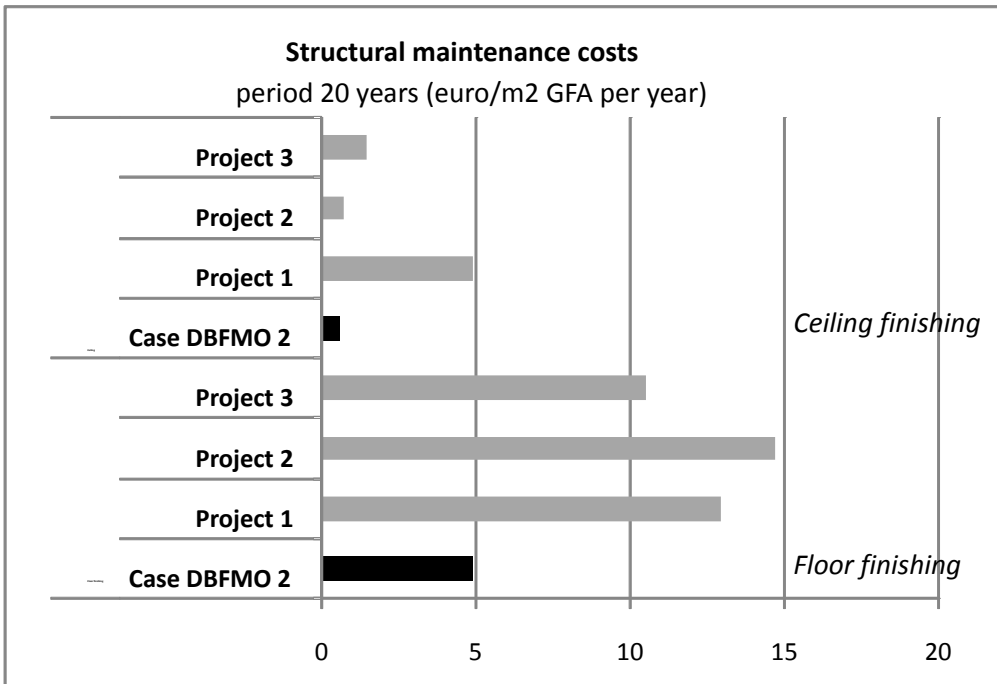


Figure 2 Maintenance costs floor and ceiling finishing DBFMO project 2 and traditional project 1,2 and 3

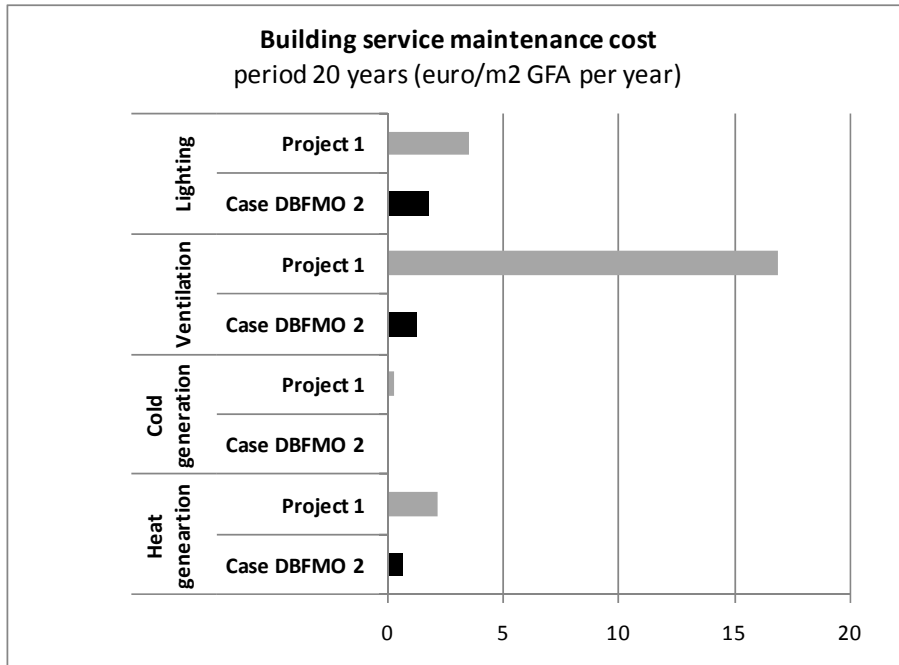


Figure 3 Maintenance costs building services DBFMO project 2 and traditional project 1

The graphs show significant lower cost levels for the DBFMO projects. The maintenance costs for floor finishing and ceiling finishing are 0.3 to 8 times lower for the DBFMO projects.

5.2 Energy-use projects

It was not possible to compare the energy consumption at element level because the data was only available per energy carrier (gas and electricity). Figure 4 shows that the DBFMO projects are performing better than the traditional projects even without corrections for longer operating time for the DBFMO cases.

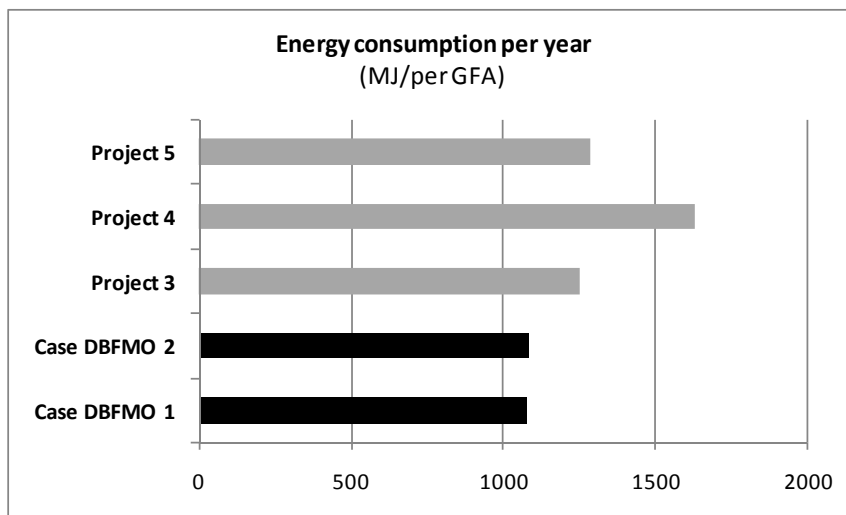


Figure 4 Energy-use DBFMO projects 1 and 2 and traditional projects 3, 4 and 5

6 Discussion

6.1 Expert interviews

By means of interviews with experts, involved in the projects, the results of the cost data and energy use analysis' were discussed, including the researchers ideas on innovations found within the DBFMO projects according to the constituted definition.

6.2 Innovations on maintenance costs

6.2.1 Floor finishing

Carpet is the dominant floor finishing in the two DBFMO projects. In case one a carpet tile is applied. During the design phase a specific carpet tile was developed by the architect, contractor and supplier, resulting in seven different tiles differing in color, weaving and pattern. The tiles are randomly produced, packed and mounted in the structure. Because of these special developed carpet tiles it is less visible when a single tile has to be replaced. The replaced tile does not stand out as a new tile in a 'carpet' with the other ones. Therefore fewer replacements are expected to take place during the operation period. This solution can be seen as an innovation on the component composition and ensemble level because this solution improved the use of a special designed and developed carpet tile. The carpet tile itself is not an innovation; the pattern that is developed that only works when seven or more tiles are placed together, can be seen as an innovation.

6.2.2 Ceiling finishing

The solution for the ceiling as applied in the DBFMO projects has an indirect link with maintenance. The choice for a climate sealing in case 1 has been based on energetic considerations. The advantage for the maintenance can be considered as indirect. The ceiling finishing for case 2 is also based on energetic considerations and therefore it is not an innovation on maintenance.

6.2.3 Heat and cold generation

In case 2 a heat pump is applied to warm and cool the structure. Out of the analysis a better performance can be discerned. However the interviewees refute this outcome. The heat pump is according to a number of interviewees more expensive on maintenance than a traditional heat system but has energetic advantages. In contrast with the data analysis the interviewees cannot see any advantages with regard to maintenance. Therefore the heat pump is not considered to be an innovation on maintenance

within the context of this research.

6.2.4 Ventilation

The choice for the ventilation concept of case 2 is driven by a maintenance point of view. The fresh air is blown into the room via a raised floor and the exhaust air is collected in the room and exhausted via a central duct. This solution entails no ventilation ducts within the office spaces. Less ventilation ducts means less maintenance. The contractor and advisors developed this solution in the design phase of the project. Therefore this solution can be seen as an innovation on maintenance.

6.2.5 Lighting

Due to lower lighting level demand less lighting elements are installed in case 2, which are compensated with individual desk lights. Interviewees could not explain the better performance that came out of the maintenance costs analysis. It can be argued that less base lighting result in less maintenance. However, interviewees argue that this is compensated by the extra individual desk lightning. So this aspect can't be seen as an innovation on maintenance.

6.3 Innovations on energy-use

6.3.1 Façade concept

The façade concepts of both DBFMO projects are not commonly applied solutions. Case 1 is in essence a renovation project. The existing structure was posing a problem for the transportation of exhaust air within the building and large thermal bridges were present. In order to overcome these two design issues, a double skin façade is applied to reduce the thermal bridges and to transport fresh and exhaust air in the façade. The individual elements cannot be seen as innovations. However, the solution as a whole is an innovation on ensemble level, which enables a reduction in energy consumption. The façade concept of case 2 is specially developed with regard to sun influences. The façade consists of a fin, which differs in length and height to optimize sun radiation and light entry in all seasons of the year. In this way a reduction of energy consumption is expected because less heating, cooling and lighting has to be applied. This second façade concept can also be seen as an innovation on ensemble level.

6.3.2 Heat and cold generation

In both DBFMO projects the heat and cold generation is produced by a heat pump. This system can generate more efficiently heat or cold in relation to traditional heating systems. Interviewees conclude

that it is a fairly normal system within offices. Therefore this is not classified as an innovation within the context of this research.

6.4 Innovations in maintenance service delivery

Besides innovations found on the physical parts, other small incremental innovations in maintenance service delivery by the DBFMO contractor were mentioned in the interviews, e.g. monitoring the condition of building components in-situ and adapted preventive maintenance schedules. These process and service innovations will have a minor effect on the maintenance costs, however might be crucial to meet the performance specifications during the concession period.

7 CONCLUSIONS

7.1 Innovations

Within the two DBFMO cases four design choices and products can be considered to be innovations effecting maintenance costs and energy-use: (1) carpet tiles, (2) ventilation concept, (3) façade case 1 and (4) façade case 2. The design choices and products perform better on maintenance costs or energy use than the traditional projects selected for comparison. The four design choices and products are new and improved solutions, related to the way the project was procured by a DBFMO model. The innovations can be considered to be rather incremental, according to the applied definition and based on the explorative part of the research.

Considering the findings of the research the DBFMO construction organization has a positive influence on the development of innovations on maintenance and energy-use. A number of conditions could be of influence on an innovative environment of DBFMO projects: the collaborative environment, the use of performance specifications, optimizing life cycle costing and risk transfer between public and private partners. The innovations found in the case studies can be considered as the successful transfer of knowledge between departments that would have worked independently in case of a traditional procured project. As the prime focused in this research was on finding real innovations in built projects comparing DBFMO to traditionally procured ones; we cannot provide detailed causal relationships on our findings and the potential causes.

7.2 Research limitations

Only two DBFMO cases were investigated due to limited number of DBFMO projects in the Netherlands, making the conclusions difficult to generalize for all DBFMO projects. However, at least indications have been found that the conditions of DBFMO projects shape an innovative environment.

The performance data of the DBFMO cases on maintenance costs and energy-use is based on prognoses, as the delivery dates were too recent for reliable actual cost data. The data used was provided by the contractor, which has made the calculations of the maintenance costs and energy-use on the basis of the preliminary designs. In this research it has been assumed that this data should reflect the real costs rather accurately, because risk-averse parties like the contractor in case are liable for these expected costs over up to two decades. The maintenance costs data and expected energy-use performance is calculated based on confidential data sets, therefore the validity could not be determined. There was no reliable data about investment costs, making life cycle costs comparisons between DBFMO cases and traditional cases not possible.

Comparing buildings on costs is in general rather problematic due to the unique character of buildings. In terms of project selection often the researchers were faced with limited available data on life cycle costs, long-term maintenance plans and energy consumption. Instead of comparing buildings as a whole it proved possible to compare a number of elements. The maintenance costs and energy consumption analysis was meant to found possible innovations and not to compare similar solutions on cost or energy consumption efficiency.

7.3 Further research

The study has to be repeated with more cases and should be based upon actual cost data and real energy performance data for better validity. Moreover further research is needed to have a better understanding of procurement models like DBFMO and innovations. Further research could be conducted on e.g. the conditions why exactly innovations arise in DBFMO projects, on the life cycle cost efficiency of projects related to innovations and on the role of the architect in a risk-avoiding environment.

Also the causal relations often assumed to be effective in case of DBFMO in terms of process and contractual characteristics related to the type and amount of innovations found needs to be further explored.

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荷蘭 DBFMO 專案中的創新解決方案

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摘要

整合性的建案承包模式, 被認為會因其合作式環境、輸出規範、長期投入等特質, 達到更省錢、更高性能、更創新等成效。因為同時考量了投資成本及營運成本, 所以可降低建物生命週期裡的加總成本。幾年前, 荷蘭政府開放民間參與公共建設的模式 (PPP, Public Private Partnership), 准許將其應用於政府建設的營建及整修。這意味著民間業者不單可參與專案的整修或新建工程, 更可投入相關的維護、服務提供、營運、籌資等項目。DBFMO (Design, Build, Finance, Maintain & Operate, 設計、營造、籌資、維護及營運) 就是這種公私協力關係的核心內涵。DBFMO 模式涵蓋了從設計規劃, 到建物完工營運並啟動所有相關服務的完整過程。本研究的目的是尋找經驗實證, 驗證以 DBFMO 模式運作的辦公大樓相較於傳統點交模式, 是否真能透過產品創新來節省維護費用及耗能。研究中假設維護成本及耗能兩者, 是 DBFMO 承包商最能直接受惠於創新解決方案的面向, 因此也最容易由此切入驗證。本研究針對兩棟 DBFMO 模式和五棟傳統點交模式的辦公大樓作出比較。研究方法包括: 深入訪談業主和承包商對 DBFMO 承包模式的看法, 維護成本和耗能計算的個案研究, 及各方參與者的專家訪談。在 DBFMO 的兩項專案中, 共找出四處產品及設計決策上的創新, 確實對後續的維護及耗能造成影響。另外, 也找到一些漸進式維護過程上的創新。這些創新有別於傳統點交模式裡的各自為政, 可視為專案參與成員之間成功的知識傳承。

關鍵字: DBFMO, 耗能, 創新, 維護成本